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MAXIMIZING LONG-TERM BENEFITS FROM SWINE MANURE NUTRIENTS APPLIED TO SASKATCHEWAN SOILS

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ABSTRACT

Field and laboratory research work was conducted over two years (2005 and 2006) at four long-term manure management research sites in Saskatchewan: Dixon, Melfort, Plenty and Riverhurst. At all four sites, swine manure has been applied at different rates and sequences for seven to ten years. A similar experiment with solid cattle manure was present at the Dixon site only. The objective was 1) to assess how different rates and sequences of application of liquid swine manure and solid cattle manure influence soil nutrient amounts and distribution, crop nutrition and yield and 2) determine the effectiveness of adding a nitrification inhibitor (Dixon site), supplemental P fertilizer (Dixon site) and S fertilizer (Melfort site) as strategies to further increase manure nitrogen recovery and crop yield.

Annual applications of injected liquid swine manure at rates of about 3000 to 4000 gallons per acre, equivalent to about 100 lbs N/acre, generally were sufficient to produce maximum yield of cereals and oilseeds at the sites and did not result in nitrogen or phosphorus over loading or evidence of deep leaching in the soil profile. Double or triple these rates applied once every second or third year respectively also did not show evidence of nutrient loading. Significant residual effects on crop yield of these larger swine manure applications were apparent into the second and third year, but additional fertilizer nutrient may be required to maximize yield in subsequent years. Rates of manure nutrient should be reduced where crop nutrient removal over the years is reduced by drought or other causes of low yield.

Supplemental fertilizer phosphorus or sulfur did not result in increased yields or N recovery in the manure treatments in 2005 and 2006, in contrast to the positive response to supplemental phosphorus that was observed in 2004 and the response to sulfur observed in 2003. Enough P and S was supplied in the manure applications to provide sufficient nutrient for crop growth under the 2005 and 2006 conditions. Supplemental fertilizer did increase the yields and N recovery in the urea fertilized only treatments. The addition of the nitrification inhibitor to the liquid swine manure had limited impact on nitrogen recovery by the crop over the two years of the study. However, it did reduce the rate of conversion of ammonium to the easily lost nitrate form following application and did contribute to some increased recovery in the early stages of crop growth. The inhibitor may be cost effective under conditions with greater N loss potential than encountered over the two years of this study.

Larger annual applications of cattle manure (~300 lbs N/acre) were required to maximize yield compared to liquid swine manure, due to a lower short-term availability of N in the cattle manure. However, at the high rates of cattle manure, excessive phosphorus loading and evidence of leaching below the 0-6 inch depth was noted. Relying on rates of cattle manure high enough to supply enough N on its own can result in loading and increased risk of loss of other nutrients like phosphorus to the environment. It is recommended to try to meet only a portion of the N requirement with cattle manure, meet but not exceed the P requirement over time and monitor soil P levels closely. With liquid swine manure, application to meet the N requirement did not result in loading of P due to a lower content of P in the manure.

TECHNICAL REPORT

This report covers field and laboratory research work conducted by the University of Saskatchewan Soil Science Department at four long-term manure research sites in Saskatchewan: Dixon, Melfort, Plenty and Riverhurst in 2005 and 2006. Results of research work conducted from 1998 to 2004 are found in previous AFIF, ADF and SaskPork reports as well as scientific publications and Proceedings of Soils and Crops Workshops (University of Saskatchewan Extension Division, on CD).

OBJECTIVES: 1) To determine how repeated applications of manure affect soil environmental quality and crop production and 2) To identify manure management practices that maximize benefits and minimize potential nutrient losses, including manure additives and nutrient balancing.

METHODOLOGY

Field Site Description and Experimental Design

This report covers field and laboratory activities in 2005 and 2006. The final report on ADF project 20010276 covers results from the 2003 and 2004 field seasons at these same sites. The following is a description of the four field sites and experimental design.

Manure Application and Sampling: Liquid swine manure was applied in the spring of 2005 and fall of 2005 after harvest using low disturbance injection coulters with the PAMI Effluent Injection truck while the cattle manure was applied by hand and incorporated using a rotary tiller. At each site each year, approximately six samples of manure are collected from the applicator during application to the plots. The manure samples were chilled and then shipped to the lab where they were frozen until analysis. The analysis and application rates of manure are provided in tables at the end of this section.

Dixon

Legal Location: NW21-37-23-W2

Cudworth Association: loamy Black Chernozemic soil on silty lacustrine parent material

History:
1997 – Canola
1998 – HRS Wheat
1999 – Barley
2000 – Canola
2001 – HRS Wheat
2002 – Flax (drought)
2003 – Barley
2004 – Canola (frost)

2005 - HRS Wheat
2006 – Flax

Special Notes: In 2002, 2003, 2004, 2005 and 2006, 15kg P_2O_5/ha of ammonium phosphate (12-51-0) was banded prior to seeding at one end of each 30m X 6m swine manure and urea plot to provide no P and P fertilized sub-plots.

Experimental Design: Randomized complete block design with four replications. Tests plots are 30m X 6m.

Manure Application: Liquid swine manure effluent from a nearby earthen storage pit was injected 10-13 cm deep into test plots using a low disturbance injector each year for 8 years (1997-2006). Cattle manure was broadcast by hand and incorporated (1997-2006).

Treatments (hog):

-3 rates of injected effluent:
- -3,300 gpa 1X including injected, broadcast & incorp., with and without nitrification inhibitor
- -6,600 gpa 2X
- -13,200 gpa 4X

-Applied in different sequences: annually, semi-annually, once every 3 yrs
-Broadcast and Incorporated effluent (3,300 gpa)
-Banded Urea (46-0-0) (low 1X 50, medium 2X 100 and high 4X 200 kg N/ha)
-Disturbed Check Strips

Treatments (cattle):

-3 rates of broadcast and incorporated manure:
- -7.6 tonnes dry equivalent/ha
- -15.2 tonnes dry equivalent/ha
- -30.4 tonnes dry equivalent/ha

Applied in different sequences, plus broadcast and 24 hour delayed incorp treatment, and three urea treatments same as for swine manure trials.

-Disturbed Check Strips

Melfort

Legal Location: SW26-44-18-W2

Melfort Association/Kamsack Association loamy Grey-Black Chernozemic soil

History:
2000 – HRS Wheat
2001 – Canola
2002 – Oats
2003 – Canola
2004 – Oats (some frost)
2005 – Canola
2006 - Barley

Special Notes: In 2002 and in 2005 separate applications of elemental sulfur and sulfate at 40 kg S/ha were banded prior to seeding at one end of each 30m X 6m swine manure and urea plot to provide sub-plots of S fertilized (two forms of S).

Experimental Design: Randomized complete block design with four replications. Tests plots are 30m X 6m.

Manure Application: Liquid swine manure from a nearby earthen storage pit was injected 10-13 cm deep into test plots using a low disturbance injector each year (2000-2006).

Treatments:

-3rates of injected effluent:

- 3000 gpa applied every year 1X
-6000 gpa applied every second year 2X0X2X
-9000 gpa applied every third year 3X0X0X

-Urea (46-0-0) (80 kg N/ha) application

-Disturbed Check Strips

Plenty

Legal Location: SW5-33-18-W3

Regina Association: heavy clay-clay Dark Brown Chernozemic soil on clay lacustrine parent material

History:
1999 – HRS Wheat
2000 – Canary Seed
2001 – Spring Wheat
2002 – Crop Failure (drought)
2003 –HRS Wheat
2004- Canary Seed
2005 – Wheat
2006 - Canola

Special Notes: Frequent poor yields due to low moisture in west-central SK over first four years. Manure application rates were reduced from 5000 gpa (1X) and 10000 gpa (2X) to 3300gpa (1X) and 6600gpa (2X) respectively after the first four years due to loading issues. There was some herbicide drift from adjacent cropland and crop injury in Regimes 1 and 2 in 2006.

Experimental Design: Randomized complete block design with three replications. Tests plots are 30m X 6m.

Manure Application: Liquid swine manure from a nearby earthen storage pit was injected 10-13 cm deep into test plots using a low disturbance injector each year (1999-2006).

Treatments:

2 rates of injected hog effluent applied in 6 sequences:
Low Rate: 5000 gpa first four years, then 3300 gpa for last four years (1X)
High Rate: 10000 gpa first four years, then 6600 gpa for last four years (2X)
Urea (46-0-0): (High rate 80 kg N/ha, Low rate 40 kg N/ha) application
Disturbed Check Strips

Riverhurst

Legal Location: SW20-24-5W3

Birsay Association: Sandy loam textured Brown Chernozemic soil on sandy glacio-lacustrine parent material

History:
1999 – Pinto Beans
2000 – Barley
2001 – Barley

2002 – Crop Failure (grasshoppers)
2003 – Wheat
2004 – Potatoes
2005 – Canola
2006 – Green Oat feed

Special Notes: Irrigated site (over 20 years). Commercial liquid fertilizer applied through pivot in 2004 for potatoes as a blanket application, including plot area of field.

Experimental Design: Randomized complete block design with three replications. Tests plots are 30m X 6m.

Manure Application: Liquid swine manure from a nearby earthen storage pit was injected 10-13 cm deep into test plots using a low disturbance injector each year (1999-2006).

Treatments:

2 rates of injected hog effluent applied in 6 sequences:

Low Rate: 5000 gpa first four years, then 3300 gpa for last four years (1X)

High Rate: 10000 gpa first four years, then 6600 gpa for last four years (2X)

-Urea (46-0-0) (High rate 80 kg N/ha, Low rate 40 kg N/ha) application

-Disturbed Check Strips

Manure Nutrient Concentrations and Application Rate
TABLES

Concentrations in *Hog Manure* Applied at Dixon Crop Site in Spring 2005 for 2005 Season

	Tot. N	NH4	NO3	Tot. P	Avail P	K	Ca	Mg	Cu	Fe	Mn	Zn
	ug/ml											
	1498	1086	-	86	15	1428	214	40	1.5	13	1.0	8
	Application rates of nutrient in kg/ha											
Rate gpa												
3330	49	36	-	2.8	0.5	47	7.1	1.3	0.05	0.4	0.03	0.3

Concentrations in *Cattle Manure* Applied at Dixon Crop Site in Spring 2005 for 2005 Season

	Tot. N	NH4	NO3	Tot. P	Avail P	K	Ca	Mg	Cu	Fe	Mn	Zn
	ug/g wet manure											
	4777	509	-	1202	7	5985	15843	4694	21.8	3171	119	40
	Application rates of nutrient in kg/ha											
Rate T/ha (dry)												
7.6	73	7.7	-	18	0.1	91	241	71	0.3	48	1.8	0.6

Concentrations in *Hog Manure* Applied at Melfort Crop Site in Spring 2005 for 2005 Season

Tot. N	NH4	NO3	Tot. P	Avail P	K	Ca	Mg	Cu	Fe	Mn	Zn
ug/ml											
1740	1603	-	75	17	1281	199	50	1.7	22	0.7	12.7

Application rates of nutrient in kg/ha

Rate gpa											
3300	57	53	-	2.5	0.6	42	6.6	1.7	0.06	0.7	0.02	0.40

Concentrations in *Hog Manure* Applied at Plenty Crop Site in Spring 2005 for 2005 Season

Tot. N	NH4	NO3	Tot. P	Avail P	K	Ca	Mg	Cu	Fe	Mn	Zn
ug/ml											
1940	1591	-	274	80	1561	290	125	3.8	23	3.5	15.3

Application rates of nutrient in kg/ha

Rate gpa											
3300	64	53	-	9.0	2.6	52	9.6	4.1	0.13	0.8	0.12	0.5

Concentrations in *Hog Manure* Applied at Irrigated Riverhurst Crop Site in Spring 2005 for 2005 Season

	Tot. N	NH4	NO3	Tot. P	Avail P	K	Ca	Mg	Cu	Fe	Mn	Zn
	ug/ml											
	2270	1842	-	114	26	1417	256	54	1.3	16	1.0	7.7

Application rates of nutrient in kg/ha

Rate gpa												
3300	75	61	-	3.8	0.9	47	8.4	1.8	0.04	0.5	0.03	0.25

Concentrations in *Hog Manure* Applied at Dixon Crop Site in Fall 2005 for 2006 Season

	Tot. N	NH4	NO3	Tot. P	Avail P	K	Ca	Mg	Cu	Fe	Mn	Zn
	ug/ml											
	2050	1297	-	156	30	1735	308	34	8.3	38	3.1	14.3
	Application rates of nutrient in kg/ha											
Rate gpa												
3330	68	43	-	5.1	1.0	57	10.2	1.1	0.27	1.2	0.10	0.5

Concentrations in *Cattle Manure* Applied at Dixon Crop Site in Fall 2005 for 2006 Season

	Tot. N	NH4	NO3	Tot. P	Avail P	K	Ca	Mg	Cu	Fe	Mn	Zn
	ug/g wet manure											
	4790	41	-	1222	92	7266	5958	2041	12.2	921	70	33
	Application rates of nutrient in kg/ha											
Rate T/ha (dry)												
7.6	73	0.6	-	19	1.4	111	91	31	0.2	14	1.1	0.5

Concentrations in *Hog Manure* Applied at Melfort Crop Site in Fall 2005 for 2006 Season

Tot. N	NH4	NO3	Tot. P	Avail P	K	Ca	Mg	Cu	Fe	Mn	Zn
ug/ml											
2235	1760	-	56	5	1408	450	135	0.8	17	1.8	7.5

Application rates of nutrient in kg/ha

Rate gpa											
3300	74	58	-	1.9	0.2	47	15	4.5	0.02	0.6	0.06	0.20

Concentrations in *Hog Manure* Applied at Plenty Crop Site in Fall 2005 for 2006 Season

Tot. N	NH4	NO3	Tot. P	Avail P	K	Ca	Mg	Cu	Fe	Mn	Zn
ug/ml											
1917	1631	-	195	119	1256	68	8	1.4	9	0.1	6

Application rates of nutrient in kg/ha

Rate gpa											
3300	63	54	-	6.5	3.9	42	2.3	0.3	0.05	0.3	0.003	0.2

Concentrations in *Hog Manure* Applied at Irrigated Riverhurst Crop Site in Fall 2005 for 2006 Season

	Tot. N	NH4	NO3	Tot. P	Avail P	K	Ca	Mg	Cu	Fe	Mn	Zn
	ug/ml											
	1493	1189	-	123	50	966	105	12	0.6	11	0.1	5.7

Application rates of nutrient in kg/ha

Rate gpa												
3300	50	39	-	4.1	1.7	32	3.5	0.4	0.02	0.4	0.003	0.19

General Yield, Plant and Soil Nutrient Assessments at All Sites

Manure and fertilizer was applied according to treatment schedule at all four sites at the end of April in 2005 for the 2005 season, and in October of 2006 for the 2006 season (see above Tables for manure nutrient concentrations and application rates at each site). The four research sites are Dixon, Melfort, Plenty and Riverhurst, Saskatchewan. The Dixon site has sub-plots of P fertilizer addition (15 kg P2O5/ha) and the Melfort site has two different forms of sulfur (elemental and sulfate @ 40 kg S/ ha) as sub-plots applied for 2005. The P fertilizer addition was repeated in 2006 but the S fertilizer addition was not, as the S fertilizer is applied only once every three years in the experimental design.

In August of 2005 and 2006, harvest samples were taken via square meters from plots. The harvest samples were threshed in September and samples were weighed. These samples were further processed for grain and straw yield and nutrient analysis conducted. Sulfuric acid digestion of grain and straw samples was performed to determine nitrogen and phosphorus content and % total N recovery (crop N uptake in treatment – crop N uptake in control divided by N addition as fertilizer or manure). At the Melfort site, nitrogen and sulfur concentrations and uptake in grain in straw was conducted using a Leco CNS analyzer.

In the fall of 2005 soil samples (0-30cm and 30-60cm) were collected from the plots after harvest and analyzed for available nutrients. In the fall of 2006, in addition to surface samples, deep sampling was conducted to 120 cm. All depth increments were analyzed for available nitrogen (ammonium and nitrate) using 2M KCl extraction, while two surface depths 0-15 and 15-30 were analyzed for available P and K using modified Kelowna extraction. The pH and EC were also measured in surface samples and sulfate was measured at the Melfort site using 0.01M CaCl2 extraction.

Effect of Nitrification Inhibitor on Early Season Nitrogen Dynamics in 2005 and 2006 Field Seasons (Dixon only)

In the spring of 2005 and in the fall of 2005 after harvest, a combination nitrification inhibitor (dicyandamide or DCD) and urease inhibitor (NBPT) was added to the tanker truck applying the swine manure at the Dixon site, following application of manure to other treatments. The rate used was the recommended rate of 0.275mL per kg of liquid manure. The manure plus inhibitor was applied to an extra 1X repeated manure application treatment that was present in the experiment and compared to a 1X repeated manure application treatment without the inhibitor added, and to the disturbed control. Bi-weekly samples of soil and plant material were taken at this site on the three treatments to monitor nitrogen dynamics. Samples taken included soil samples, tissue samples, and PRS probes were placed in the plots in nests to measure ammonium and nitrate supply rates over successive two week intervals from seeding until late July. Soil samples were taken to a depth of 0-15 cm every two weeks with a Dutch auger. Plant

samples for biomass assessment were taken over a 10 cm^2 area every two weeks. PRS probes were placed in PVC cores to exclude plant root competition for nutrients and placed in the soil after seeding and were replaced bi-weekly until the dough stage of the crop. Anion PRS probes were used to monitor nitrate and phosphate while cation PRS probes were used to measure ammonium (NH_4^+). One meter square plant samples were taken from all swine manure and cattle manure plots as for harvest from all sites. These samples were dried and harvested for analysis of grain and straw yield and nitrogen.

Plant samples (10 cm^2) were dried and weighed to determine total N uptake by the crop throughout the growing season. A sulfuric acid digestion was performed on the biweekly plant samples (10 cm^2) and analyzed using the Technicon AutoAnalyzer for total N and P. PRS probes were eluted then analyzed for nitrate (anion), phosphate (anion) and ammonium (cation) with the Technicon AutoAnalyzer. Harvest samples of all plots were threshed and yield data collected. Sulfuric acid digestion of grain and straw samples was performed to determine nitrogen content and total N recovery based on yield data. Fall soil samples were taken from all swine and cattle manure plots to a depth of 60 cm, in 30 cm increments. Fall soil samples were analyzed using 2 M KCL (nitrate and ammonium) and Kelowna (extractable P and K) extractions.

Controlled Environment Leaching Study (Dixon only)

In October of 2004, intact soil cores (0-15cm depth) were collected from the Dixon site treatments of control (no manure or fertilizer), 1X and 4X annual applications of liquid swine manure and solid cattle manure. The cores were frozen, then thawed and a leaching experiment conducted in which 10 cm of water was passed through the cores and the leachate was analyzed for organic and inorganic phosphorus and nitrogen forms.

RESULTS AND DISCUSSION

Treatment Effects on Yield, Plant and Soil Nutrients

2005 FIELD SEASON
(Complete tabular presentation of results and statistical analysis in Tables 1A-6A at the end of the 2005 field season discussion)

Dixon Swine Manure Experiment 2005 (Table 1A)

There were some significant residual effects of manure applications made two years ago at the 2X and 4X rates: with wheat yields more than double the yield in the control (Figure 1). For the annual application sequence of swine manure, the yield was generally maximized with the 2X treatment, probably because the N content of the manure that was applied for the 2005 season was relatively low compared to other years. Compared to the urea only treatments, at equivalent rates of N the manure treatments all yielded significantly higher, in the order of about a 1000 kg/ha yield advantage observed with the manure. As in all previous years, injection of manure produced significantly higher yields than broadcast and incorporate (~3400 kg/ha vs 2400 kg/ha). The grain yield in

the treatment with the nitrification inhibitor added to the manure (Treatment 10) is not significantly higher than the yield at the same rate without inhibitor (Treatment 4). The swine manure treatments are significantly out-yielding the urea treatments, especially at high rates. Limitations of other nutrients like phosphorus are probably holding back yield in the urea only treatments. The effect of supplemental P fertilizer was to significantly increase yields of treatments in which swine manure was applied two years previously, but did not have a large impact on annual addition swine manure treatments. It may be that enough P is added with the annual treatments to balance crop demand over time, as has been shown previously. Observing some response at 1X annual application but not at 2X and 4X annual application is consistent with elevated soil P and P surplus that was reported in these treatments in measurements made in 2004.

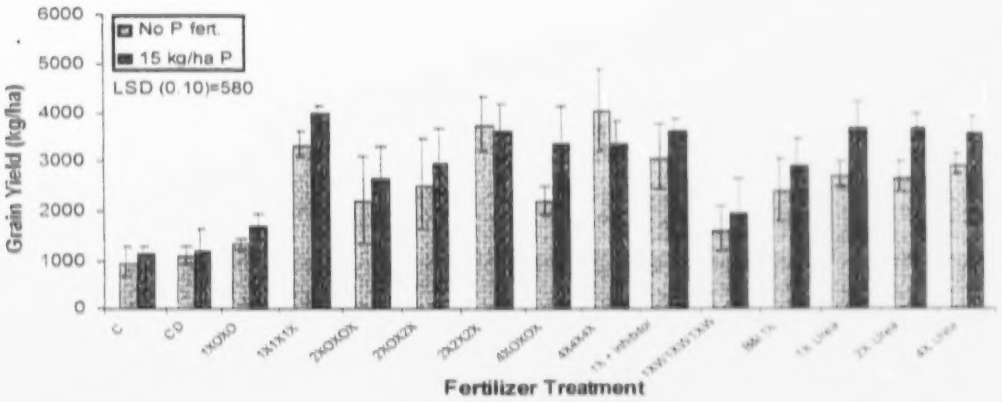


Figure 1. Wheat grain yield (kg/ha) in 2005 for all treatments with and without P fertilizer in Dixon swine manure experiment.

As in previous years, addition of swine manure significantly increased grain and straw nitrogen concentrations, and grain protein content. The addition of the nitrification inhibitor did not significantly affect grain or straw N concentrations and the treatments with and without inhibitor had very similar concentrations (example grain N concentration 1.88%N with and without inhibitor in –P treatment). As there was no significant effect of the inhibitor on yield or N concentration, N uptake was not significantly affected. Grain and straw phosphorus concentrations were not greatly affected by manure rate, and tended to decrease slightly from the control at the 1X and 2X rates compared to the control, likely because of yield dilution due to the manure N greatly enhancing increasing yield.

Nitrogen recovery by the crop was calculated using the following equation:

$$\text{Apparent \% Recovery} = \frac{\text{(Treatment uptake - Control uptake)}}{\text{Total amount of nutrient applied}} \times 100$$

Treatments 1XM (no inhibitor) and 1XM + Inh (inhibitor) are treatments of interest (Figure 2). There were no significant differences between the treatment that received the nitrification inhibitor (1XM + Inh) and the one that did not (1XM). This indicates that the nitrification inhibitor was not successful in increasing the overall nitrogen recovery by the crop in the 2005 field season. The 1X urea treatment resulted in the highest recovery of all fertilizer treatments. As expected, as rate of application of manure or urea increased, the percentage recovery decreased.

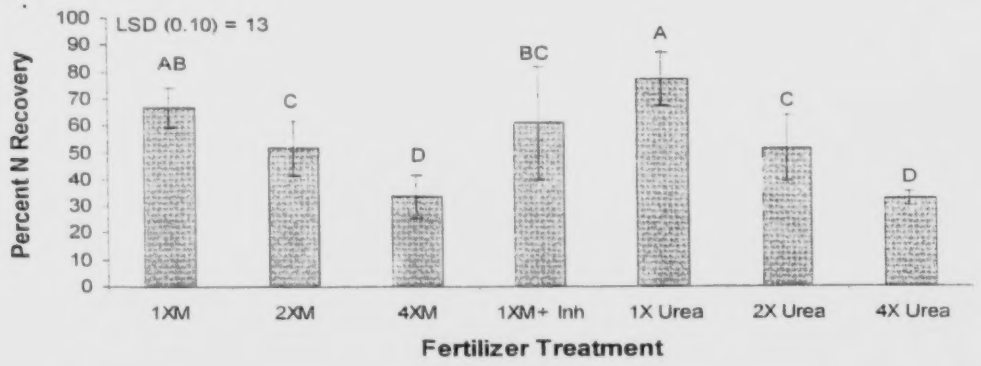


Figure 2. Recovery of applied manure or urea nitrogen in the wheat crop for seven fertilizer treatments at Dixon in 2005. Bars followed by a different letter are significantly different.

There were no significant differences in nitrogen recovery as affected by added P fertilizer with the exception of the 1X Urea treatment. The 1X Urea +P treatment resulted in a significantly higher recovery of nitrogen compared to the same treatment without supplemental phosphorus fertilizer. The addition of P fertilizer had the greatest effect on percentage N recovery in the low rate urea treatments, where the addition of P fertilizer had some positive effect on enhancing recovery of the added N. This is presumably due to the added P fertilizer alleviating a P deficiency and thereby increasing growth and crop demand and uptake of N.

As for the effect of the inhibitor treatments on yield (Figure 3), the three main treatments of interest at the Dixon site are presented. Both the 1X (37,000L ha^{-1}) and 1X+Inh (37,000L ha^{-1} + nitrification inhibitor) had significantly higher grain yield compared to the control, but neither were significantly different from one another.

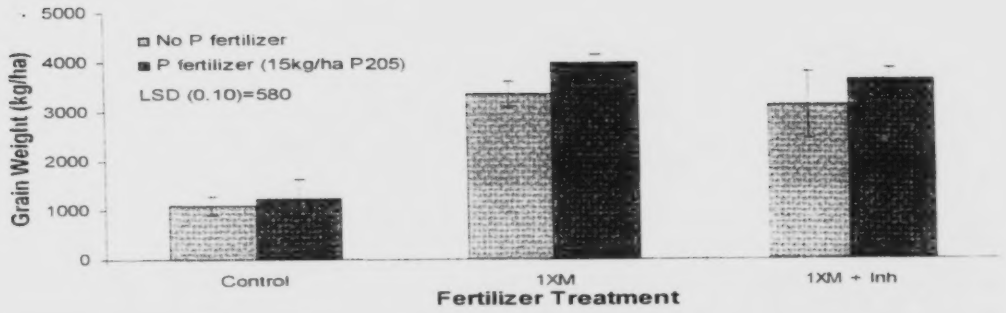


Figure 3. Wheat grain yield comparison between the control, 1XM (37,000 L ha^{-1}) and 1XM + Inh (37,000 L ha^{-1} + nitrification inhibitor) receiving P fertilizer vs. no P fertilizer.

Surface (0-30cm) and sub-soil (30-60cm) nitrate contents were significantly enhanced over the control in the 2X and 4X annual application rate sequences. The 1X treatment resulted in only small elevations (<10 kg/ha) of nitrate above the unfertilized control in both the surface and sub-soil. The higher rates applied once every three years ie 2X-0-0 and 4X-0-0 did not show any significant differences from the unfertilized control. It may be concluded as in previous years, that treatments that cause excessive nitrate loading are those treatments in which swine manure is injected every year at 2X and 4X the agronomic rate. The inhibitor did not have a significant effect on nitrate content in the soil profile, with similar nitrate contents in the 0-30 and 30-60 cm depths for treatments 4 and 10. There is a trend for the nitrate contents with the inhibitor to be slightly lower. The addition of phosphorus did not have a significant effect on soil nitrate content. Phosphorus fertilization did result in consistently higher Kelowna extractable P in all treatments as would be expected. The manure treatment effects on extractable P were only significant for the 4X annual application rate treatment, with significant elevation above other treatments. Other rates and sequences are not significantly different from one another, indicating that P loading is only an issue with the excessive (4X rate). As was observed in other years, soil extractable K was significantly increased by manure addition in accordance with rate and frequency of application.

Dixon Cattle Manure Experiment 2005 (Table 2A)

A significant effect of cattle manure applications made two years ago (once every three years) on wheat yield over the control is evident, with 2X-0-0 and 4X-0-0 treatments yielding 600 to 1000 kg/ha over the unfertilized control. The 1X-0-0 treatment is not significantly different from the control. This application treatment does not appear to be adding enough nutrient or organic matter to significantly benefit yield. However, the 1X, 2X and 4X annual additions have the effect of producing significant yield increases with increasing rate. The 4X annual addition rate has the highest wheat yield (~ 4000 kg/ha)

and this yield is significantly higher than the 2X annual addition rate. This yield is similar to that observed for swine manure. Applying cattle manure every year at the 4X rate appears to be necessary to maximize yield. As in previous years, there was no significant difference in yield between broadcast and immediate incorporation of the cattle manure versus a 24 hr delay in incorporation. This type of manure with significant amounts of straw and not much ammonium does not seem susceptible to volatilization losses. Delay of incorporation for 24 hours would appear to be suitable. At lower application rates of N, the urea yields are significantly better than the cattle manure treatments, indicating that the 1X and 2X annual or less frequent application rates of cattle manure are still not supplying enough nitrogen for maximum crop growth.

Wheat grain and straw nitrogen concentrations were increased by cattle manure addition, with increasing rate producing increased grain and straw N concentration. As expected, the highest grain and straw nitrogen concentrations were observed in the 4X annual application treatment. Grain phosphorus concentrations were slightly elevated by cattle manure addition and straw P concentrations tended to be higher in the cattle manure treatments than in the swine manure treatments at this site. This is consistent with the cattle manure containing and adding more phosphorus to the soil.

Additions of cattle manure significantly increased the Kelowna extractable P concentrations over the control and urea only fertilized treatments. Soil extractable P significantly increased with rate, to a maximum of 165 kg / ha of Kelowna extractable P in the 0-30cm depth at the 4X annual rate. Kelowna extractable K concentrations were also more than doubled at the 4X annual rate compared to the control. It appears that if the 4X annual addition rate treatment was used to supply N and maximize yield alone, that significant loading of soil P and K would result. Reflecting the lower release rate of nitrate by mineralization and lower N availability from cattle manure compared to swine manure, significant elevations in surface and sub-soil nitrate were not observed in the 1X and 2X annual applications and 4X every third year cattle manure treatments. Only in the 4X annual cattle manure application was there a significant elevation over other manure treatments, and the nitrate contents in this treatment were less than the urea 4X treatment. Clearly, it is only the 4X rate applied every year for the last nine years in which concern might arise about nitrate leaching. This treatment represents about 3600 kg N/ha added as manure over the last nine years.

Melfort Swine Manure Experiment 2005 (Table 3A)

At the Melfort site in 2005, canola was the crop grown. At this site, the manure 2X rate is added only every second year and 3X added only once every three years. The residual effect of adding once every two years at double rate (2X-0) is evident, with significantly higher canola yield than the unfertilized control (1100 kg/ha versus 375 kg/ha) (Figure 4).

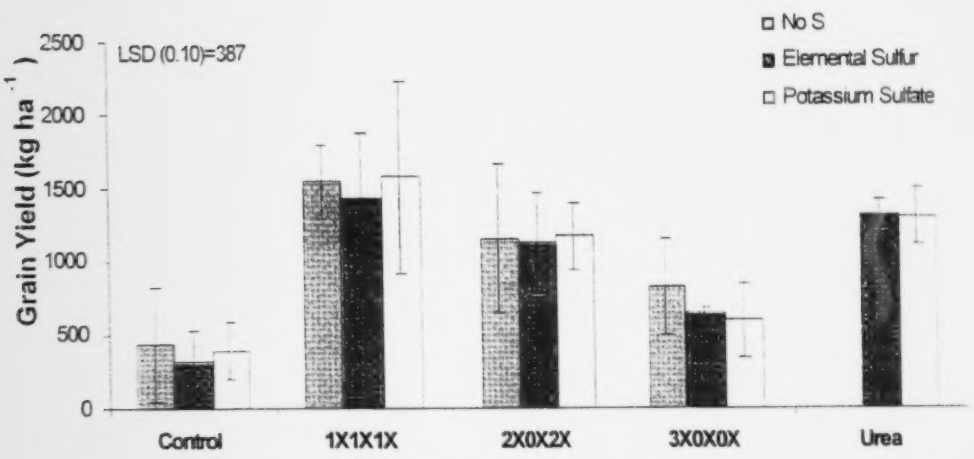


Figure 4. Comparison of canola seed yield in the manure and fertilizer treatments at Melfort in 2005 without and with supplemental fertilizer added as elemental S (S^0) and sulfate (SO_4). The 1X treatment represents an annual application while the 2X and 3X treatments represent residual effects from previous years.

The 1X annual addition rate treatment still produced the highest grain and straw yield. The 3X-0-0 still had some residual effect in year 3, with a yield near double that of the unfertilized control. The residual effect of the 2X-0 treatment is similar to that observed at the Dixon site. S deficiency and N:S interaction is a significant limitation on canola yield at this site, as the soil is inherently S deficient. Reflecting this, the seed yield of the 1X urea treatment without supplemental S was 1 kg/ha (essentially zero seed yield of canola) while with S, the seed yield was ~ 1300 kg/ha. Even with added S, the seed yields of the urea fertilized canola were still less than the manure treatments, perhaps due to P depletion, although the extractable P levels in the urea fertilized treatments are not greatly different than the manure fertilized treatments. On control treatments, S fertilization had no effect on yield and all yields were ~ 300 to 400 kg/ha. For the 1X annual swine manure addition rate, S fertilization had no significant effect on yield and it would appear that the 1X annual addition rate supplies enough S. Also for the 2X-0 treatment, S fertilization had no significant effect on yield. Overall, S limitation in manure treatments was not a factor in 2005, despite growing a high S demanding, S deficiency sensitive crop like canola. This is supported by the soil sulfate analysis, in which manure treatments contained higher amounts of sulfate in the 0-30cm depth in the fall after harvest than the urea treatment, although not statistically significantly different.

Swine manure and urea addition tended to increase canola grain N concentration and reduce straw N concentration in the treatments with supplemental S fertilizer. Both canola grain and straw S concentrations were significantly increased by S fertilizer addition in the manure treatments, indicating that the supplemental S fertilizer added was being taken up and utilized by the canola. This is not surprising as the S fertilizer treatments were applied in the spring of 2005. There was little difference between the elemental and sulfate forms in their effect on yield and plant S concentrations.

Nitrogen recovery of the 1X1X1X (annual application of swine manure) treatment with and without supplemental sulfur fertilizers showed consistently higher percentage nitrogen recovery compared to the higher application rates of swine manure made every second or third year, as the 2X0X2X and 3X0X0X treatments did not receive an application of swine manure for the current year (2005) in the spring. There were no significant differences in apparent nitrogen recovery within fertilizer treatments with the exception of the urea fertilizer treatments (Figure 5). The addition of elemental sulfur (S) and potassium sulfate (SO4) significantly increased the nitrogen recovery over the urea no S treatment. This site experiences sulfur deficiency and addition of N alone, as in the urea treatment, induces severe S deficiency in high S demanding crops like canola. The lack of response to supplemental fertilizer S in manure treatments in 2005 suggests that sufficient S was supplied or carried over in the manure treatments. In previous years however, a response to supplemental S fertilizer has been observed in the manure treatments.

Figure 5. Percentage of applied N recovered by canola at Melfort site in 2005 with no S fertilizer, with elemental sulfur (S), and with potassium sulfate (SO_4) added at 40 kg S / ha to manure and urea fertilizer treatments.

All treatments in the fall after harvest had similar, low (<2 kg/ha) nitrate nitrogen contents in the sub-soil (30-60cm depth), and had nitrate contents in the 0-30cm depth around 10 kg/ha that differed little among treatments. These results are similar to those observed at the Dixon site, where annual applications at the 1X rate, along with larger applications made every second or third year, were not associated with significant nitrate loading or migration. Soil extractable P levels in manure and urea fertilized treatments at this site are also similar or below that of the control soil, indicating that P loading is also not occurring in manure treatments at this site.

Plenty Swine Manure Experiment 2005 (Table 4A)

Swine manure addition nearly tripled spring wheat yields at this site in 2005 compared to the unfertilized control (3000 kg/ha in 1X annual application versus 1000 kg/ha in unfertilized control). Increasing manure rate from 1X to 2X annual application did not significantly affect grain yield. There was, in fact, a slight decrease in yield going from 1X annual application to 2X annual application for both swine manure and urea. This may be a "haying off" effect where the stimulation of extra vegetative growth at the higher rate resulted in greater depletion of soil moisture early in the season, leaving insufficient water for grain fill later on. In many cases, yields that were achieved with the 1X and 2X rates applied the year before (1X-0 and 2X-0 treatments) were as high as treatments that received manure that year and every year. Equivalent or better yields at reduced frequency of application, even for the 1X treatment, suggests that reduced frequency is best at this site, likely because there is significant residual soil N from previous years. This is born out by soil nitrate contents in the reduced frequency regime 5 that are elevated and similar to the annual application regime 6.

As at the other sites, grain and straw N concentrations reflect manure or fertilizer N application rate and frequency history. Increasing frequency and rate of manure application resulted in increased grain and straw N concentrations as expected. Grain and straw P concentrations increased slightly with increasing application frequency, reflecting greater total manure P input.

Fall soil nitrate contents (0-60cm) were low in the control (18 kg NO_3-N / ha) but were greatly elevated in the swine manure treatments, with upwards of 700 kg / ha of nitrate nitrogen in the soil profile in the high rate (2X) annual and reduced frequency regimes. Nitrate loading above 100 kg N/ha 0-60 cm was also noted in the 1X annual and reduced frequency treatments. Nitrate levels were not elevated in the urea fertilizer treatments. Very high levels of soil nitrate at this site reflect past application rate history, with the first three years of the experiment having very high application of manure N. This, coupled with two drought years with low crop N uptake and removal, reduced deep leaching due to heavy texture, contribute to a build-up of nitrate, even at 1X rates. At this site, similar elevations in soil extractable P are noted in 1X swine manure treatments not observed at other sites. Again, this can be attributed to high rates of manure and also manure of high P content (pre-phytase period) that was applied in the first years of the study.

Riverhurst Swine Manure Experiment 2005 (Table 5A)

In 2004, this site had a blanket application of ~ 150 kg N/ha across every treatment, including the control, made through the irrigation pivot when potatoes were grown. The residual effect is evident in a lack of treatment effect on yield in 2005. There was no significant effect of swine manure or fertilizer treatment on canola yield, with high (~2700 kg/ha) and quite consistent yields among treatments.

Manure application did significantly increase canola grain and straw N concentration and uptake over the unfertilized control at this site. The additional N uptake may be considered luxury uptake as no yield increases were associated with the additional N made available by adding manure. At this site, manure addition also resulted in significant increases in phosphorus concentration in both the straw and the grain. This is consistent with the significant elevation in soil extractable phosphorus content associated with swine manure addition at this site.

Soil nitrate contents were elevated above the control and urea fertilized treatments with manure addition and with increased application frequency, similar to that observed at the Plenty site. However, the elevations in profile nitrate content in 1X and 2X manure treatments are not nearly as large as that observed at the Plenty site. Both sites have the same application history, including high rates of manure nutrient in the first few years. However, lower soil nitrate loading at Riverhurst is a likely consequence of greater crop removal and also perhaps deep leaching, as this site is irrigated.

2005 Field Season Yield, Crop and Soil Nutrients
TABLES 1A to 6A

TABLE 1A. Dixon Swine Manure Site 2005 Yield, Crop & Soil Nutrients

2005 Wheat Crop Harvest — Hog Manure Amended Plots

Rate of Manure Application-One Time

Trt	Rate 1997	1998	1999	2000	2001	2002	2003	2004	2005	N	Crop Harvest Fall 2005 Grain Yld	Straw Yld	Crop Sample N & P Analysis Grain N	Straw N	Grain P	Straw P	Soil Analysis (0-30 cm) NO_3	NH_4	P	K	Soil Analysis (30-60 cm) NO_3	NH_4
2	0	0	0	0	0	0	0	0	0	4	1095 183	1186 247	14585 627	2307 166	2998 292	732 551	8.9 2.0	11.9 5.4	30.7 7.4	863.1 222.7	3.0 0.7	13.3 9.3
3	1	0	0	1	0	0	1	0	0	4	1337 117	1754 684	15313 600	2257 98	3146 131	801 722	9.4 2.0	14.1 6.9	28.3 7.8	915.3 127.5	2.3 1.0	13.5 2.2
5	2	0	0	2	0	0	2	0	0	4	2250 890	2843 1136	15536 810	2420 195	2956 329	467 325	11.3 4.6	14.3 4.6	27.1 11.8	965.8 117.0	4.0 1.3	13.1 4.9
8	4	0	0	4	0	0	4	0	0	4	2221 300	2804 301	16278 1145	2573 548	3404 427	436 497	11.1 1.4	9.6 4.7	37.0 15.6	1150.5 396.9	3.0 1.0	18.5 2.7

Rate of Manure Application-Annual

Trt	Rate 1997	1998	1999	2000	2001	2002	2003	2004	2005	N	Crop Harvest Fall 2005 Grain Yld	Straw Yld	Crop Sample N & P Analysis Grain N	Straw N	Grain P	Straw P	Soil Analysis (0-30 cm) NO_3	NH_4	P	K	Soil Analysis (30-60 cm) NO_3	NH_4
2	0	0	0	0	0	0	0	0	0	4	1095 183	1186 247	15313 627	2307 166	2998 292	732 551	8.9 2.0	11.9 5.4	30.7 7.4	863.1 222.7	2.3 1.0	13.3 9.3
4	1	1	1	1	1	1	1	1	1	4	3359 255	4654 300	18800 2442	3731 1105	2841 322	62 63	16.4 6.7	15.4 5.4	25.7 3.3	1055.7 203.2	8.5 4.8	16.0 6.5
7	2	2	2	2	2	2	2	2	2	4	3755 558	5260 1016	22401 355	5600 737	2481 144	37 49	23.3 11.2	14.5 7.0	32.4 14.3	1338.7 259.4	35.9 33.6	32.5 3.0
9	4	4	4	4	4	4	4	4	4	4	4062 831	6368 1482	23905 1070	6986 660	2686 225	37 24	33.8 20.4	16.1 8.9	53.8 29.6	1511.4 223.6	209.0 164.5	37.0 5.1

Rate of Manure Application-Annual & Skipped

Trt	Rate 1997	1998	1999	2000	2001	2002	2003	2004	2005	N	Crop Harvest Fall 2005 Grain Yld	Straw Yld	Crop Sample N & P Analysis Grain N	Straw N	Grain P	Straw P	Soil Analysis (0-30 cm) NO_3	NH_4	P	K	Soil Analysis (30-60 cm) NO_3	NH_4
2	0	0	0	0	0	0	0	0	0	4	1095 183	1186 247	14585 627	2307 166	2998 292	732 551	8.9 2.0	11.9 5.4	30.7 7.4	863.1 222.7	3.0 0.7	11.3 9.3
3	1	0	0	1	0	0	1	0	0	4	1337 117	1754 684	15313 600	2257 98	3146 131	801 722	9.4 2.0	14.1 6.9	28.3 7.8	915.3 127.5	2.3 1.0	13.5 2.2
4	1	1	1	1	1	1	1	1	1	4	3359 255	4654 300	18800 2442	3731 1105	2841 322	62 63	16.4 6.7	15.4 5.4	25.7 3.3	1055.7 203.2	8.5 4.8	16.0 6.5
5	2	0	0	2	0	0	2	0	0	4	2250 890	2843 1136	15536 810	2420 195	2956 329	467 325	11.3 4.6	14.3 4.6	27.1 11.8	965.8 117.0	4.0 1.3	13.1 4.9
7	2	2	2	2	2	2	2	2	2	4	3755 558	5260 1016	22401 355	5600 737	2481 144	37 49	23.3 11.2	14.5 7.0	32.4 14.3	1338.7 259.4	35.9 33.6	32.5 3.0
8	4	0	0	4	0	0	4	0	0	4	2221 300	2804 301	16278 1145	2573 548	3404 427	436 497	11.1 1.4	9.6 4.7	37.0 15.6	1150.5 396.9	3.0 1.0	18.5 2.7
9	4	4	4	4	4	4	4	4	4	4	4062 831	6368 1482	23905 1070	6986 660	2686 225	37 24	33.8 20.4	16.1 8.9	53.8 29.6	1511.4 223.6	209.0 164.5	37.0 5.1
										LSD	588	930	1304	626	392	420	7.1	9.7	12.3	220.7	65.6	20.1

Method of Manure Application-Annual

Trt	Method	N	Grain Yld.	Straw Yld.	Crop Sample N & P Analysis Grain N	Straw N	Grain P	Straw P	Soil Analysis (0-30 cm) NO_3	NH_4	P	K	Soil Analysis (30-60 cm) NO_3	NH_4
1	Control-Average	4	978 283	1150 251	14018 1062	2452 431	3179 204	801 643	7.9 2.2	9.4 2.5	27.8 3.9	881.1 184.2	3.3 1.2	24.3 7.2
2	Control-Disturbed	4	1095 183	1186 247	15313 627	2307 166	2998 292	732 551	8.9 2.0	11.9 5.4	30.7 7.4	863.1 222.7	2.3 1.0	13.3 9.3
4	1X1X1X1X1X1X1X Injection @12	4	3359 255	4654 300	18800 2442	3731 1105	2841 322	62 63	16.4 6.7	15.4 5.4	25.7 3.3	1055.7 203.2	8.5 4.8	16.0 6.5
10	1X1X1X1X1X1X1X Injection@ 12" + INHIBITOR	4	3110 671	4925 1365	18768 668	3259 361	2820 312	15 4	13.2 2.6	14.5 1.9	35.1 12.7	940.2 172.4	6.0 3.8	17.2 3.5
11	1X1X1X1X1X1X1X ++H2O	4	1631 447	2097 899	15774 806	2292 174	2997 155	726 699	9.7 1.7	10.9 4.2	28.3 12.6	980.6 248.9	3.0 0.7	24.0 10.0
12	1X1X1X 1X1X1X1XBroadcast & Incorporated	4	2444 636	3288 918	15729 99	2104 217	2984 281	131 156	12.9 0.7	25.0 6.1	27.0 9.1	1140.3 270.6	3.4 1.3	18.3 0.2

Source and Rate of Annual N Application-Balanced

Trt		Rate 1997	1998	1999	2000	2001	2002	2003	2004	2005	N	Crop Harvest Fall 2005 Grain Yld	Straw Yld	Crop Sample N & P Analysis Grain N	Straw N	Grain P	Straw P	Soil Analysis (0-30 cm) NO_3	NH_4	P	K	Soil Analysis (30-60 cm) NO_3	NH_4
2	Hog	0	0	0	0	0	0	0	0	0	4	1095 183	1186 247	15313 627	2307 166	2998 292	732 551	8.9 2.0	11.9 5.4	30.7 7.4	863.1 222.7	2.3 1.0	13.3 9.3
4	Hog	1	1	1	1	1	1	1	1	1	4	3359 255	4654 300	18800 2442	3731 1105	2841 322	62 63	16.4 6.7	15.4 5.4	25.7 3.3	1055.7 203.2	8.5 4.8	16.0 6.5
7	Hog	2	2	2	2	2	2	2	2	2	4	3755 558	5260 1016	22401 355	5600 737	2481 144	37 49	23.3 11.2	14.5 7.0	32.4 14.3	1338.7 259.4	35.9 33.6	32.5 3.0
9	Hog	4	4	4	4	4	4	4	4	4	4	4062 831	6368 1482	23905 1070	6986 660	2686 225	37 24	33.8 20.4	16.1 8.9	53.8 29.6	1511.4 223.6	209.0 164.5	37.0 5.1
1	Hog	0	0	0	0	0	0	0	0	0	4	978 283	1150 251	14018 1062	2452 431	3179 204	801 643	7.9 2.2	9.4 2.5	27.8 3.9	881.1 184.2	3.3 1.2	24.3 7.2
13	Urea	1	1	1	1	1	1	1	1	1	4	2753 261	3913 761	14018 1062	2452 431	3179 204	801 643	7.9 2.2	9.4 2.5	27.8 3.9	881.1 184.2	3.3 1.2	24.3 7.2
14	Urea	2	2	2	2	2	2	2	2	2	4	2705 285	4216 815	18018 1294	3250 600	2218 678	16 13	11.5 2.2	12.5 8.7	25.5 11.0	745.1 172.0	4.2 1.2	23.1 9.4
15	Urea	4	4	4	4	4	4	4	4	4	4	2955 191	4603 282	21553 1384	4192 752	2110 393	16 11	14.9 3.2	17.2 8.0	22.7 2.6	738.0 23.8	44.7 32.6	21.9 8.2
														23043 1315	5148 558	2162 301	18 7	17.0 3.6	18.0 6.0	22.2 4.4	962.5 235.2	120.6 139.7	12.7 5.9

Alternating Hog Manure Application

Trt	Rate 1997	1998	1999	2000	2001	2002	2003	2004	2005	N	Crop Harvest Fall 2005 Grain Yld	Straw Yld	Crop Sample N & P Analysis Grain N	Straw N	Grain P	Straw P	Soil Analysis (0-30 cm) NO_3	NH_4	P	K	Soil Analysis (30-60 cm) NO_3	NH_4
1	0	0	0	0	0	0	0	0	0	4	978 283	1150 251	14018 1062	2452 431	3179 204	801 643	7.9 2.2	9.4 2.5	27.8 3.9	881.1 184.2	3.3 1.2	24.3 7.2
2	0	0	0	0	0	0	0	0	0	4	1095 183	1186 247	15313 627	2307 166	2998 292	732 551	8.9 2.0	11.9 5.4	30.7 7.4	863.1 222.7	3.0 0.7	13.3 9.3
5	2	0	0	2	0	0	2	0	0	4	2250 890	2843 1136	15536 810	2420 195	2956 329	467 325	11.3 4.6	14.3 4.6	27.1 11.8	965.8 117.0	4.0 1.3	13.1 4.9
6	2	2	2	2	2	2	2	2	0	4	2550 911	3720 425	17940 1775	2817 334	3079 713	369 542	12.5 1.4	9.5 3.2	28.3 7.5	1114.3 327.8	6.5 4.4	12.5 9.8
7	2	2	2	2	2	2	2	2	2	4	3755 558	5260 1016	22401 355	5600 737	2481 144	37 49	23.3 11.2	14.5 7.0	32.4 14.3	1338.7 259.4	35.9 33.6	32.5 3.0
										LSD	588	930	1304	626	392	420	7.1	9.7	12.3	220.7	65.6	20.1

Note: 1. Crop harvest (grain and straw yields) means in kg ha^{-1}
2. Grain and Straw Total N and Total P means in kg g^{-1}
3. Soil Extractable NH_4, NO_3, P & K means in kg ha^{-1}
4. Means in the first column are followed by standard deviations in the second column.
5. N=Number of observations
6. LSD (0.10) calculated at $p \leq 0.10$

TABLE 1A (Continued). Dixon Swine Manure Site 2005 Results

2005 Wheat Crop Harvest — Hog Manure + Fertilizer Phosphorus Amended Plots

Rate of Manure Application-One Time

Trt	Rate 1997	1998	1999	2000	2001	2002	2003	2004	2005	N	Crop Harvest Fall 2005 Grain Yld		Straw Yld		Crop Sample N & P Analysis Grain N		Straw N		Grain P		Straw P		Soil Analysis (0-30 cm) NO_3		NH_4		P		K		Soil Analysis (30-60 cm) NO_3		NH_4	
2	0	0	0	0	0	0	0	0	0	4	1226	392	1655	537	15428	954	2349	117	2961	154	924	439	11.6	3.3	10.5	4.0	43.5	14.9	785.7	189.6	1.9	0.9	13.6	11.4
3	1	0	0	1	0	0	1	0	0	4	1693	257	1812	455	16067	256	2408	402	3389	297	1358	641	12.2	3.9	8.8	3.4	35.9	3.3	929.1	206.5	3.4	2.0	22.0	22.5
5	2	0	0	2	0	0	2	0	0	4	2666	672	3616	1309	16859	946	2465	221	3322	240	689	174	10.9	3.4	9.1	4.3	34.5	9.3	1002.7	232.8	3.4	1.2	33.5	27.7
8	4	0	0	4	0	0	4	0	0	4	3398	756	4495	1248	18321	2534	2683	976	3319	236	458	384	14.1	3.2	6.8	2.0	48.1	5.1	1211.6	175.4	10.4	13.5	10.2	8.0

Rate of Manure Application-Annual

Trt	Rate 1997	1998	1999	2000	2001	2002	2003	2004	2005	N																								
2	0	0	0	0	0	0	0	0	0	4	1226	392	1655	537	15428	954	2349	117	2961	154	924	439	11.6	3.3	10.5	4.0	43.5	14.9	785.7	189.6	1.9	0.9	13.6	11.4
4	1	1	1	1	1	1	1	1	1	4	3983	161	5878	666	20726	1445	3792	323	2916	83	26	20	19.5	5.3	9.0	3.8	42.1	3.4	1104.8	263.9	9.9	7.1	5.0	3.8
7	2	2	2	2	2	2	2	2	2	4	3627	561	6129	934	24064	424	6492	1180	2613	131	14	5	23.6	5.9	8.3	3.6	46.0	10.2	1376.7	275.5	76.8	46.4	35.5	34.8
9	4	4	4	4	4	4	4	4	4	4	3405	398	6056	432	25460	1016	8682	631	3452	255	591	321	37.3	16.0	9.8	2.0	80.1	34.7	1539.3	666.8	175.5	169.2	50.1	32.9

Rate of Manure Application-Annual & Skipped

Trt	Rate 1997	1998	1999	2000	2001	2002	2003	2004	2005	N																								
2	0	0	0	0	0	0	0	0	0	4	1226	392	1655	537	15428	954	2349	117	2961	154	924	439	11.6	3.3	10.5	4.0	43.5	14.9	785.7	189.6	1.9	0.9	13.6	11.4
3	1	0	0	1	0	0	1	0	0	4	1693	257	1812	455	16067	256	2408	402	3389	297	1358	641	12.2	3.9	8.8	3.4	35.9	3.3	929.1	206.5	3.4	2.0	22.0	22.5
4	1	1	1	1	1	1	1	1	1	4	3983	161	5878	666	20726	1445	3792	323	2916	83	26	20	19.5	5.3	9.0	3.8	42.1	3.4	1104.8	263.9	9.9	7.1	5.0	3.8
5	2	0	0	2	0	0	2	0	0	4	2666	672	3616	1309	16859	946	2495	221	3322	240	689	174	10.9	3.4	9.1	4.3	34.5	9.3	1002.7	232.8	3.4	1.2	33.5	27.7
7	2	2	2	2	2	2	2	2	2	4	3627	561	6129	934	24064	424	6492	1180	2613	131	14	5	23.6	5.9	8.3	3.6	46.0	10.2	1376.7	275.5	76.8	46.4	35.5	34.8
8	4	0	0	4	0	0	4	0	0	4	3398	756	4495	1248	18321	2534	2683	976	3319	236	458	384	14.1	3.2	6.8	2.0	48.1	5.1	1211.6	175.4	10.4	13.5	10.2	8.0
9	4	4	4	4	4	4	4	4	4	4	3405	398	6056	432	25460	1016	8682	631	3452	255	591	321	37.3	16.0	9.8	2.0	80.1	34.7	1539.3	666.8	175.5	169.2	50.1	32.9
LSD —										7		585		1016		1427		917		264		347		6.7		3.3		15.2		295.4		58.4		25.8

Method of Manure Application-Annual

Trt	Method	N	Grain Yld		Straw Yld		Crop Sample N & P Analysis Grain N		Straw N		Grain P		Straw P		Soil Analysis (0-30 cm) NO_3		NH_4		P		K		Soil Analysis (30-60 cm) NO_3		NH_4	
1	Control-Average	4	1161	100	1190	177	14855	548	2321	419	3239	153	937	569	9.5	4.8	6.8	0.8	37.3	10.3	871.6	296.8	2.3	1.4	18.9	12.7
2	Control-Disturbed	4	1226	392	1655	537	15428	954	2349	117	2961	154	924	439	11.6	3.3	10.5	4.0	43.5	14.9	785.7	189.6	1.9	0.9	13.6	11.4
4	1X1X1X1X1X1X1X Injection @12"	4	3983	161	5878	666	20726	1445	3792	323	2916	83	26	20	19.5	5.3	9.0	3.8	42.1	3.4	1104.8	263.9	9.9	7.1	5.0	3.8
10	1X1X1X1X1X1X1X Injection @12" + INHIBITOR	4	3637	235	6056	544	19229	2723	3755	1360	2966	292	20	12	15.7	2.5	8.2	3.9	45.6	12.8	992.1	102.8	13.8	10.1	22.6	19.7
11	1X1X1X1X1X1X1X +H2O	4	1983	668	2972	1414	16013	485	2167	218	3268	142	1146	659	12.3	3.4	8.1	1.1	28.7	6.9	955.2	157.4	3.1	1.7	37.2	40.8
12	1X1X1X 1X1X1X1X Broadcast & Incorporated	4	2946	534	3756	1441	16856	586	2357	130	3146	111	595	472	13.4	3.5	9.5	3.2	39.8	9.6	1070.1	266.6	4.3	1.7	9.6	11.3

Source and Rate of Annual N Application-Balanced

Trt		Rate 1997	1998	1999	2000	2001	2002	2003	2004	2005	N																								
2	Hog	0	0	0	0	0	0	0	0	0	4	1226	392	1655	537	15428	954	2349	117	2961	154	924	439	11.6	3.3	10.5	4.0	43.5	14.9	785.7	189.6	1.9	0.9	13.6	11.4
4	Hog	1	1	1	1	1	1	1	1	1	4	1983	161	5878	666	20726	1445	3792	323	2916	83	26	20	19.5	5.3	9.0	3.8	42.1	3.4	1104.8	263.9	9.9	7.1	5.0	3.8
7	Hog	2	2	2	2	2	2	2	2	2	4	3627	561	6129	934	24064	424	6492	1180	2613	131	14	5	23.6	5.9	8.3	3.6	46.0	10.2	1376.7	275.5	76.8	46.4	35.5	34.8
9	Hog	4	4	4	4	4	4	4	4	4	4	3405	398	6056	432	25460	1016	8682	631	3452	255	591	321	37.3	16.0	9.8	2.0	80.1	34.7	1539.3	666.8	175.5	169.2	50.1	32.9
1	Hog	0	0	0	0	0	0	0	0	0	4	1161	100	1190	177	14855	548	2321	419	3239	153	937	569	9.5	4.8	6.8	0.8	37.3	10.3	871.6	296.8	2.3	1.4	18.9	12.7
13	Urea	1	1	1	1	1	1	1	1	1	4	3710	505	5400	558	17734	929	2757	635	2972	338	21	20	14.1	3.4	7.0	1.8	37.3	18.2	957.6	321.0	7.2	4.2	16.2	15.2
14	Urea	2	2	2	2	2	2	2	2	2	4	3710	244	5590	533	22733	1066	4920	721	2433	190	25	5	15.4	3.5	7.9	2.3	36.6	2.9	772.6	71.3	16.2	12.3	11.8	8.3
15	Urea	4	4	4	4	4	4	4	4	4	4	3574	342	5804	516	24323	795	6371	1578	2419	214	31	14	18.8	4.3	8.7	3.0	35.3	12.6	817.1	163.0	78.0	56.6	6.4	2.2

Alternating Hog Manure Application

Trt	Rate 1997	1998	1999	2000	2001	2002	2003	2004	2005	N																								
1	0	0	0	0	0	0	0	0	0	4	1161	100	1190	177	14855	548	2321	419	3239	153	937	569	9.5	4.8	6.8	0.8	37.3	10.3	871.6	296.8	2.3	1.4	18.9	12.7
2	0	0	0	0	0	0	0	0	0	4	1226	392	1655	537	15428	954	2349	117	2961	154	924	439	11.6	3.3	10.5	4.0	43.5	14.9	785.7	189.6	1.9	0.9	13.6	11.4
5	2	0	0	2	0	0	2	0	0	4	2666	672	3616	1309	16859	946	2495	221	3322	240	689	174	10.9	3.4	9.1	4.3	34.5	9.3	1002.7	232.8	3.4	1.2	33.5	27.7
6	2	0	2	2	0	2	0	2	0	4	2999	670	3632	1108	17251	232	2452	419	3224	335	531	481	11.9	2.2	9.1	2.2	39.9	17.8	1052.2	244.5	4.5	2.0	25.8	20.2
7	2	2	2	2	2	2	2	2	2	4	3627	561	6129	934	24064	424	6492	1180	2613	131	14	5	23.6	5.9	8.3	3.6	46.0	10.2	1376.7	275.5	76.8	46.4	35.5	34.8
LSD —										7		585		1016		1427		917		264		347		6.7		3.3		15.2		295.4		58.4		25.8

Note 1. Crop harvest (grain and straw yields) means in ka ha^{-1}
2. Grain and Straw Total N and Total P means in ug g^{-1}
3. Soil Extractable NH4, NO3, P & K means in ka ha^{-1}
4. Means in the first column are followed by standard deviations in the second column
5. Phosphorus was added in 2005 at a rate of 30kg/ha of 11-51-0
6. N=Number of observations
7. LSD (0.10) calculated at p ≤ 0.10

TABLE 1A (Continued). Dixon Swine Manure Site 2005 Results

2005 Wheat Crop Harvest

Combined Plots: Hog Manure and No Phos Plots with Hog Manure + Phosphorus Amended Plots

Rate of Manure Application-One Time

Trt	Rate 1997	1998	1999	2000	2001	2002	2003	2004	2005
2	0	0	0	0	0	0	0	0	0
3	1	0	0	1	0	0	1	0	0
5	2	0	0	2	0	0	2	0	0
8	4	0	0	4	0	0	4	0	0

Rate of Manure Application-Annual

Trt	Rate 1997	1998	1999	2000	2001	2002	2003	2004	2005
2	0	0	0	0	0	0	0	0	0
4	1	1	1	1	1	1	1	1	1
7	2	2	2	2	2	2	2	2	2
9	4	4	4	4	4	4	4	4	4

Rate of Manure Application-Annual & Skipped

Trt	Rate 1997	1998	1999	2000	2001	2002	2003	2004	2005
2	0	0	0	0	0	0	0	0	0
3	1	0	0	1	0	0	1	0	0
4	1	1	1	1	1	1	1	1	1
5	2	0	0	2	0	0	2	0	0
7	2	2	2	2	2	2	2	2	2
8	4	0	0	4	0	0	4	0	0
9	4	4	4	4	4	4	4	4	4

Method of Manure Application-Annual

Trt	Method
1	Control-Average
2	Control-Disturbed
4	1X1X1X1X1X1X1X Injection @ 12
10	1X1X1X1X1X1X1X Injection @ 12 + Herbitor
11	1X1X1X1X1X1X1X + H2O
12	1X1X1X 1X1X1X1XBroadcast & Incorporated

Source and Rate of Annual N Application-Balanced

Trt		Rate 1997	1998	1999	2000	2001	2002	2003	2004	2005
2	Hog	0	0	0	0	0	0	0	0	0
4	Hog	1	1	1	1	1	1	1	1	1
7	Hog	2	2	2	2	2	2	2	2	2
9	Hog	4	4	4	4	4	4	4	4	4
1	Hog	0	0	0	0	0	0	0	0	0
13	Urea	1	1	1	1	1	1	1	1	1
14	Urea	2	2	2	2	2	2	2	2	2
15	Urea	4	4	4	4	4	4	4	4	4

Alternating Hog Manure Application

Trt	Rate 1997	1998	1999	2000	2001	2002	2003	2004	2005
1	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0
5	2	0	0	2	0	0	2	0	0
6	2	0	2	2	0	2	0	2	0
7	2	2	2	2	2	2	2	2	2

Trt	N	Crop Harvest Fall 2005: Grain Yld. No Phos		Grain Yld. + Phos		Straw Yld. No Phos		Straw Yld. + Phos		Grain Sample N & P Analysis: Grain N No Phos		Grain N + Phos		Grain P No Phos		Grain P + Phos		StrawSample N & P Analysis: Straw N No Phos		Straw N + Phos		Straw P No Phos		Straw P + Phos	
2	4	1096	183	1226	392	1186	247	1655	537	14585	627	15428	954	2998	292	2961	154	2307	166	2349	117	732	551	924	439
3	4	1337	117	1693	257	1754	684	1812	455	15313	600	16067	256	3146	131	3389	297	2257	98	2408	402	601	722	1358	641
5	4	2250	890	2666	672	2843	1136	3616	1309	15536	810	16859	946	2956	329	3322	240	2420	196	2495	221	467	325	689	174
8	4	2221	300	3398	756	2804	301	4495	1249	18278	1145	18321	2534	3404	427	3319	236	2573	548	2683	976	436	497	468	384
2	4	1096	183	1226	392	1186	247	1655	537	14585	627	15428	954	2998	292	2961	154	2307	166	2349	117	732	551	924	439
3	4	1337	117	1693	257	1754	684	1812	455	15313	600	16067	256	3146	131	3389	297	2257	98	2408	402	601	722	1358	641
4	4	3359	255	3983	161	4654	300	5878	666	18800	2442	20726	1445	2841	322	2916	83	3731	1105	3792	323	62	63	26	20
7	4	3755	558	3627	561	5260	1016	6129	934	22401	355	24064	424	2481	144	2613	131	2420	196	2495	221	467	325	689	174
9	4	4062	831	3405	398	6368	1482	6056	432	23905	1070	25480	1016	2686	225	3452	255	5600	737	6492	1180	37	49	14	5
																		2573	548	2683	976	436	497	468	384
																		6086	660	8682	631	37	24	591	321
LSD →		588		586		930		1016		1304		1427		392		264		626		917		420		347	

Trt	N	Grain Yld. No Phos		Grain Yld. + Phos		Straw Yld. No Phos		Straw Yld. + Phos		Grain Sample N & P Analysis: Grain N No Phos		Grain N + Phos		Grain P No Phos		Grain P + Phos		StrawSample N & P Analysis: Straw N No Phos		Straw N + Phos		Straw P No Phos		Straw P + Phos	
1	4	978	283	1161	100	1150	251	1190	177	14018	1062	14855	548	3179	204	3239	153	2452	431	2321	419	801	643	937	569
2	4	1096	183	1226	392	1186	247	1655	537	15313	627	15428	954	2998	292	2961	154	2307	166	2349	117	732	551	924	439
4	4	3359	255	3983	161	4654	300	5878	666	18800	2442	20726	1445	2841	322	2916	83	3731	1105	3792	323	62	63	26	20
10	4	3110	671	3637	235	4925	1365	6056	544	18768	668	19229	2723	2820	312	2966	262	3259	391	3755	1360	15	4	20	12
11	4	1631	447	1983	668	2097	899	2972	1414	15774	606	16013	485	2997	155	3268	142	2292	174	2187	218	728	699	1146	858
12	4	2444	636	2946	534	3286	918	3756	1441	15729	99	16856	586	2964	281	3146	111	2104	217	2397	130	131	156	585	472

Trt		N	Grain Yld. No Phos		Grain Yld. + Phos		Straw Yld. No Phos		Straw Yld. + Phos		Grain Sample N & P Analysis: Grain N No Phos		Grain N + Phos		Grain P No Phos		Grain P + Phos		StrawSample N & P Analysis: Straw N No Phos		Straw N + Phos		Straw P No Phos		Straw P + Phos	
2	Hog	4	1096	183	1226	392	1186	247	1655	537	15313	627	15428	954	2998	292	2961	154	2307	166	2349	117	732	551	924	439
4	Hog	4	3359	255	3983	161	4654	300	5878	666	18800	2442	20726	1445	2841	322	2916	83	3731	1105	3792	323	62	63	26	20
7	Hog	4	3755	558	3627	561	5260	1016	6129	934	22401	355	24064	424	2481	144	2613	131	5600	737	6492	1180	37	49	14	5
9	Hog	4	4062	831	3405	398	6368	1482	6056	432	23905	1070	25480	1016	2686	225	3452	255	2452	431	2321	419	801	643	937	569
1	Hog	0	978	283	1161	100	1150	251	1190	177	14018	1062	14855	548	3179	204	3239	153	3260	600	2757	635	18	13	21	20
13	Urea	1	2753	261	3710	505	3913	761	5400	558	18018	1294	17734	929	2218	678	2972	338	4192	752	4920	721	18	11	25	5
14	Urea	2	2705	285	3710	244	4216	818	5590	533	21553	1364	22733	1089	2110	393	2433	190	5148	558	6371	1578	18	7	31	14
15	Urea	4	2956	191	3574	342	4803	262	5804	516	23043	1315	24323	795	2162	301	2419	214								

Trt		N	Grain Yld. No Phos		Grain Yld. + Phos		Straw Yld. No Phos		Straw Yld. + Phos		Grain Sample N & P Analysis: Grain N No Phos		Grain N + Phos		Grain P No Phos		Grain P + Phos		StrawSample N & P Analysis: Straw N No Phos		Straw N + Phos		Straw P No Phos		Straw P + Phos	
1		4	978	283	1161	100	1150	251	1190	177	14018	1062	14855	548	3179	204	3239	153	2452	431	2321	419	801	643	937	569
2		4	1096	183	1226	392	1186	247	1655	537	15313	627	15428	954	2998	292	2961	154	2307	166	2349	117	732	551	924	439
5		4	2250	890	2666	672	2843	1136	3616	1309	15536	810	16859	946	2956	329	3322	240	2420	196	2495	221	467	325	689	174
6		4	2550	911	2999	670	3720	425	3632	1108	17940	1775	17251	232	3079	713	3224	335	2817	334	2452	419	369	542	531	481
7		4	3755	558	3627	561	5260	1016	6129	934	22401	355	24064	424	2481	144	2613	131	5600	737	6492	1180	37	49	14	5
LSD →			588		586		930		1016		1304		1427		392		264		626		917		420		347	

Note: 1. Crop harvest for grain and straw yields= means in kg/ha
2. Grain and Straw Total N and Total P means in kg/ha
3. Soil Extractable NH4, NO3, P & K means in kg/ha
4. Means in the first column are followed by standard deviations in the second column
5. Phosphorus was added in 2005 at a rate of 30kg/ha of 11-51-0
6. N=Number of observations
7. LSD (0.10) calculated at p = 0.10

TABLE 1A. Dixon Swine Manure Site 2005 SOIL Results SUMMARY

2005 Wheat Crop Harvest

Combined Plots: Hog Manure and No Phos Plots with Hog Manure + Phosphorus Amended Plots

Rate of Manure Application-One Time

Trt	Rate 1997	1998	1999	2000	2001	2002	2003	2004	2005	N
2	0	0	0	0	0	0	0	0	0	4
3	1	0	0	1	0	0	1	0	0	4
5	2	0	0	2	0	0	2	0	0	4
8	4	0	0	4	0	0	4	0	0	4

Soil Analysis (0-30 cm)

NO_3 No Phos		NO_3 + Phos		NH_4 No Phos		NH_4 + Phos		P No Phos		P + Phos		K No Phos		K + Phos	
8.9	2.0	11.6	3.3	11.9	5.4	10.5	4.0	30.7	7.4	43.5	14.9	863.1	222.7	785.7	189.6
9.4	2.0	12.2	3.9	14.1	6.9	9.5	3.4	28.3	7.8	35.9	3.3	915.0	127.5	929.1	206.5
11.3	4.6	10.9	3.4	14.3	4.6	9.1	4.3	27.1	11.8	34.5	9.3	965.8	117.0	1002.7	232.8
11.1	1.4	14.1	3.2	9.6	4.7	6.8	2.0	37.0	15.6	46.1	5.1	1150.5	398.9	1211.6	175.4

Soil Analysis (30-60 cm)

NO_3 No Phos		NO_3 + Phos		NH_4 No Phos		NH_4 + Phos	
3.0	0.7	1.9	0.9	13.3	9.3	13.6	11.4
2.3	1.0	3.4	2.0	13.5	2.2	22.0	22.5
4.0	1.3	3.4	1.2	13.1	4.9	33.5	27.7
3.0	1.0	10.4	13.5	18.5	2.7	10.2	8.0

Rate of Manure Application-Annual

Trt	Rate 1997	1998	1999	2000	2001	2002	2003	2004	2005	N
2	0	0	0	0	0	0	0	0	0	4
4	1	1	1	1	1	1	1	1	1	4
7	2	2	2	2	2	2	2	2	2	4
9	4	4	4	4	4	4	4	4	4	4

Soil Analysis (0-30 cm)

NO_3 No Phos		NO_3 + Phos		NH_4 No Phos		NH_4 + Phos		P No Phos		P + Phos		K No Phos		K + Phos	
8.9	2.0	11.6	3.3	11.9	5.4	10.5	4.0	30.7	7.4	43.5	14.9	863.1	222.7	785.7	189.6
16.4	6.7	19.5	5.3	15.4	5.4	9.0	3.8	25.7	3.3	42.1	3.4	1055.7	203.2	1104.8	263.9
23.3	11.2	23.6	5.9	14.5	7.0	8.3	3.6	32.4	14.3	46.0	10.2	1338.7	259.4	1376.7	275.5
33.8	20.4	37.3	18.0	16.1	8.9	9.8	2.0	53.8	29.6	80.1	34.7	1511.4	223.6	1539.3	666.8

Soil Analysis (30-60 cm)

NO_3 No Phos		NO_3 + Phos		NH_4 No Phos		NH_4 + Phos	
2.3	1.0	1.9	0.9	13.3	9.3	13.6	11.4
8.5	4.8	9.9	7.1	16.0	6.5	5.0	3.8
35.9	33.6	76.8	46.4	32.5	3.0	35.5	34.8
209.0	164.5	175.5	169.2	37.0	5.1	50.1	32.9

Rate of Manure Application-Annual & Skipped

Trt	Rate 1997	1998	1999	2000	2001	2002	2003	2004	2005	N
2	0	0	0	0	0	0	0	0	0	4
3	1	0	0	1	0	0	1	0	0	4
4	1	1	1	1	1	1	1	1	1	4
5	2	0	0	2	0	0	2	0	0	4
7	2	2	2	2	2	2	2	2	2	4
8	4	0	0	4	0	0	4	0	0	4
9	4	4	4	4	4	4	4	4	4	4

Soil Analysis (0-30 cm)

NO_3 No Phos		NO_3 + Phos		NH_4 No Phos		NH_4 + Phos		P No Phos		P + Phos		K No Phos		K + Phos	
8.9	2.0	11.6	3.3	11.9	5.4	10.5	4.0	30.7	7.4	43.5	14.9	863.1	222.7	785.7	189.6
9.4	2.0	12.2	3.9	14.1	6.9	8.9	3.4	28.3	7.8	35.9	3.3	915.0	127.5	929.1	206.5
16.4	6.7	19.5	5.3	15.4	5.4	9.0	3.8	25.7	3.3	42.1	3.4	1055.7	203.2	1104.8	263.9
11.3	4.6	10.9	3.4	14.3	4.6	9.1	4.3	27.1	11.8	34.5	9.3	965.8	117.0	1002.7	232.8
23.3	11.2	23.6	5.9	14.5	7.0	8.3	3.6	32.4	14.3	46.0	10.2	1338.7	259.4	1376.7	275.5
33.8	20.4	37.3	18.0	16.1	8.9	9.8	2.0	53.8	29.6	80.1	34.7	1511.4	223.6	1539.3	666.8
LSD		7.1		6.7		9.7		3.3		12.3		15.2		220.7	

Soil Analysis (30-60 cm)

NO_3 No Phos		NO_3 + Phos		NH_4 No Phos		NH_4 + Phos	
3.0	0.7	1.9	0.9	13.3	9.3	13.6	11.4
2.3	1.0	3.4	2.0	13.5	2.2	22.0	22.5
8.5	4.8	9.9	7.1	16.0	6.5	5.0	3.8
4.0	1.3	3.4	1.2	13.1	4.9	33.5	27.7
35.9	33.6	76.8	46.4	32.5	3.0	35.5	34.8
3.0	1.0	10.4	13.5	18.5	2.7	10.2	8.0
209.0	164.5	175.5	169.2	37.0	5.1	50.1	32.9
		65.6		55.4		23.1		25.8	

Method of Manure Application-Annual

Trt	Method	N
1	Control-Average	4
2	Control-Disturbed	4
4	1X1X1X1X1X1X1X Injection @12"	4
10	1X1X1X1X1X1X1X Injection @12" + INHIBITOR	4
11	1X1X1X1X1X1X1X + H2O	4
12	1X1X1X 1X1X1X1XBroadcast & Incorporated	4

Soil Analysis (0-30 cm)

NO_3 No Phos		NO_3 + Phos		NH_4 No Phos		NH_4 + Phos		P No Phos		P + Phos		K No Phos		K + Phos	
7.9	2.2	9.5	4.8	9.4	2.5	6.8	0.8	27.8	3.9	37.3	10.3	881.1	184.2	871.6	296.8
8.9	2.0	11.6	3.3	11.9	5.4	10.5	4.0	30.7	7.4	43.5	14.9	863.1	222.7	785.7	189.6
16.4	6.7	19.5	5.3	15.4	5.4	9.0	3.8	25.7	3.3	42.1	3.4	1055.7	203.2	1104.8	263.9
23.3	11.2	23.6	5.9	14.5	7.0	8.3	3.6	35.1	12.7	45.6	12.8	940.2	172.4	992.1	102.8
17.2	2.6	15.7	2.5	14.5	1.9	8.2	3.9	28.3	12.6	28.7	6.9	950.6	248.9	959.2	157.4
9.7	1.7	12.3	3.4	10.9	4.2	8.1	1.1	28.3	12.6	28.7	6.9	1140.3	270.6	1070.1	266.6
12.9	0.7	13.4	3.5	25.0	6.1	9.5	3.2	27.0	9.1	39.8	9.6				

Soil Analysis (30-60 cm)

NO_3 No Phos		NO_3 + Phos		NH_4 No Phos		NH_4 + Phos	
3.3	1.2	2.3	1.4	24.3	7.2	18.9	12.7
2.3	1.0	1.9	0.9	13.3	9.3	13.6	11.4
8.5	4.8	9.9	7.1	16.0	6.5	5.0	3.8
6.0	3.6	13.8	10.1	17.2	3.5	22.6	19.7
3.0	0.7	3.1	1.7	24.0	10.0	37.2	40.8
3.4	1.3	4.3	1.7	18.3	0.2	9.6	11.3

Source and Rate of Annual N Application-Balanced

Trt		Rate 1997	1998	1999	2000	2001	2002	2003	2004	2005	N
2	Hog	0	0	0	0	0	0	0	0	0	4
4	Hog	1	1	1	1	1	1	1	1	1	4
7	Hog	2	2	2	2	2	2	2	2	2	4
9	Hog	4	4	4	4	4	4	4	4	4	4
1	Hog	0	0	0	0	0	0	0	0	0	4
13	Urea	1	1	1	1	1	1	1	1	1	4
14	Urea	2	2	2	2	2	2	2	2	2	4
15	Urea	4	4	4	4	4	4	4	4	4	4

Soil Analysis (0-30 cm)

NO_3 No Phos		NO_3 + Phos		NH_4 No Phos		NH_4 + Phos		P No Phos		P + Phos		K No Phos		K + Phos	
8.9	2.0	11.6	3.3	11.9	5.4	10.5	4.0	30.7	7.4	43.5	14.9	863.1	222.7	785.7	189.6
16.4	6.7	19.5	5.3	15.4	5.4	9.0	3.8	25.7	3.3	42.1	3.4	1055.7	203.2	1104.8	263.9
23.3	11.2	23.6	5.9	14.5	7.0	8.3	3.6	53.8	29.6	80.1	34.7	1511.4	223.6	1539.3	666.8
33.8	20.4	37.3	18.0	16.1	8.9	9.8	2.0	37.3	10.3	44.5	14.9	881.1	184.2	871.6	296.8
7.9	2.2	9.5	4.8	9.4	2.5	6.8	0.8	27.8	3.9	42.1	3.4	745.1	172.0	957.6	321.0
11.5	2.2	14.1	3.4	12.5	8.7	7.0	1.8	25.5	11.0	37.3	18.2	738.0	23.8	772.6	73.3
14.9	3.2	15.4	3.5	17.2	8.0	7.9	2.3	22.7	2.6	35.6	2.9	962.5	235.2	817.1	163.0
17.0	3.6	18.8	4.3	18.0	6.0	8.7	3.0	22.2	4.4	35.3	12.6				

Soil Analysis (30-60 cm)

NO_3 No Phos		NO_3 + Phos		NH_4 No Phos		NH_4 + Phos	
2.3	1.0	1.9	0.9	13.3	9.3	13.6	11.4
8.5	4.8	9.9	7.1	16.0	6.5	5.0	3.8
35.9	33.6	76.8	46.4	32.5	3.0	35.5	34.8
209.0	164.5	175.5	169.2	37.0	5.1	50.1	32.9
3.3	1.2	2.3	1.4	24.3	7.2	18.9	12.7
4.2	1.2	7.2	4.2	23.1	0.4	16.2	15.2
44.7	32.6	16.2	12.3	21.9	8.2	11.8	8.3
120.6	130.7	78.0	58.6	12.7	5.9	6.4	2.2

Alternating Hog Manure Application

Trt	Rate 1997	1998	1999	2000	2001	2002	2003	2004	2005	N
1	0	0	0	0	0	0	0	0	0	4
2	0	0	0	0	0	0	0	0	0	4
5	2	0	0	2	0	0	2	0	0	4
6	2	0	2	2	0	2	0	2	0	4
7	2	2	2	2	2	2	2	2	2	4

Soil Analysis (0-30 cm)

NO_3 No Phos		NO_3 + Phos		NH_4 No Phos		NH_4 + Phos		P No Phos		P + Phos		K No Phos		K + Phos	
7.9	2.2	9.5	4.8	9.4	2.5	6.8	0.8	27.8	3.9	37.3	10.3	881.1	184.2	871.6	296.8
8.9	2.0	11.6	3.3	11.9	5.4	10.5	4.0	30.7	7.4	43.5	14.9	863.1	222.7	785.7	189.6
11.3	4.6	10.9	3.4	14.3	4.6	9.1	4.3	27.1	11.8	34.5	9.3	965.8	117.0	1002.7	232.8
12.5	1.4	11.9	2.2	9.5	3.2	9.1	2.2	28.3	7.5	39.9	17.8	1114.3	327.8	1052.2	244.5
23.3	11.2	23.6	5.9	14.5	7.0	8.3	3.6	32.4	14.3	46.0	10.2	1338.7	259.4	1376.7	275.5
LSD		7.1		6.7		9.7		3.3		12.3		15.2		220.7	

Soil Analysis (30-60 cm)

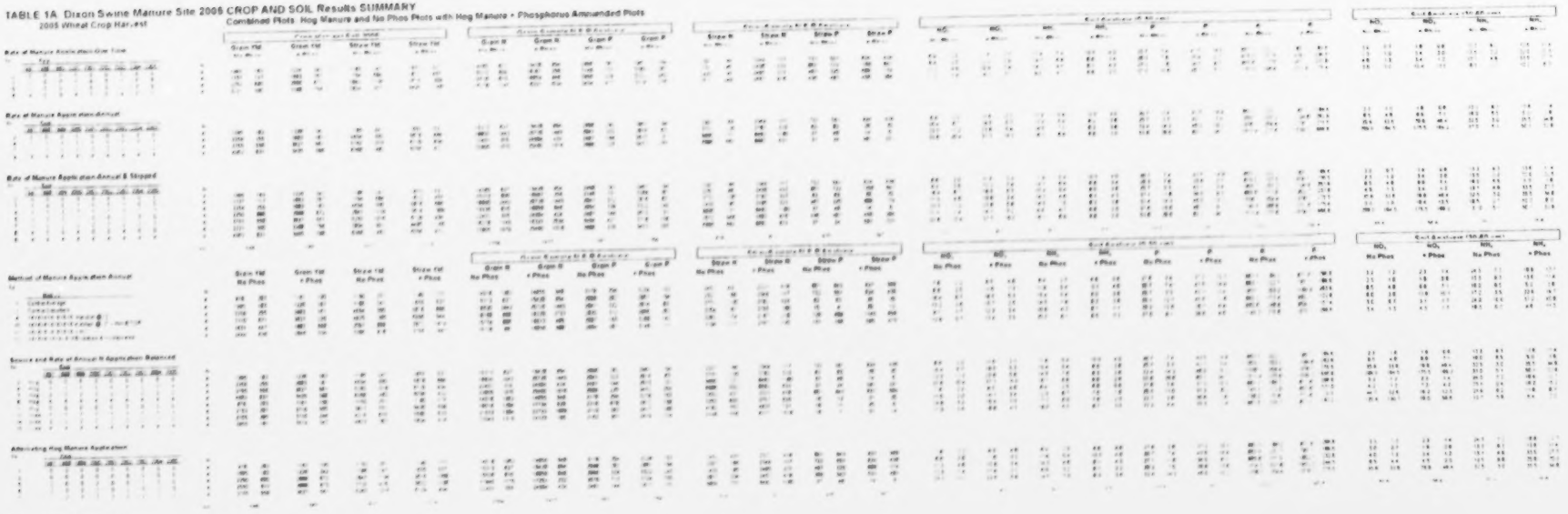
NO_3 No Phos		NO_3 + Phos		NH_4 No Phos		NH_4 + Phos	
3.3	1.2	2.3	1.4	24.3	7.2	18.9	12.7
3.0	0.7	1.9	0.9	13.3	9.3	13.6	11.4
4.0	1.3	3.4	1.2	13.1	4.9	33.5	27.7
6.5	4.4	4.5	2.0	12.5	9.8	25.8	20.2
35.9	33.6	76.8	46.4	32.5	3.0	35.5	34.8
		65.6		56.4		23.1		25.8	

Note 1. Crop harvest (grain and straw yields) means in kg/ha.
2. Grain and Straw Total N and Total P means in kg/kg.
3. Soil Extractable NH4, NO3 P & K means in kg/ha.
4. Means in the first column are followed by standard deviations in the second column.
5. Phosphorus was added in 2005 at a rate of 30kg/ha of 11-51-0.
6. N=number of observations.
7. LSD (0.10) calculated at p = 0.10.

TABLE 1A Dixon Swine Manure Site 2006 CROP AND SOIL Results SUMMARY

2006 Wheat Crop Harvest

Combined Plots Hog Manure and No Phos Plots with Hog Manure + Phosphorus Amounded Plots



Rate of Manure Application Annual & Skipped

Method of Manure Application Annual

Source and Rate of Annual N Application Balanced

Alternating Hog Manure Application

TABLE 2A. Dixon Cattle Manure Site 2005 Yield, Crop and Soil Nutrients

2005 Wheat Crop Harvest

Rate of Manure Application-One Time

Trt	Rate 1997	1998	1999	2000	2001	2002	2003	2004	2005	N	Crop Harvest Fall 2005 Grain Yld.		Straw Yld.		Crop Sample N & P Analysis Grain N	Straw N	Grain P	Straw P	Soil Analysis (0-30 cm) NO_3	NH_4	P	K	Soil Analysis (30-60 cm) NO_3	NH_4
1	0	0	0	0	0	0	0	0	0	4	1349	249	1427	270	15445 1183	2089 93	3160 292	1173 339	11.3 4.6	13.6 6.3	35.0 7.6	1011.1 105.2	2.0 2.3	26.4 19.7
2	1	0	0	1	0	0	0	1	0	4	1344	361	1599	421	15373 901	2210 245	3117 180	1195 319	11.4 4.6	11.6 4.4	35.1 7.9	1063.2 138.7	2.1 2.4	27.3 20.5
4	2	0	0	2	0	0	2	0	0	4	2097	327	2648	618	15692 760	2225 196	3220 183	1271 357	17.0 8.9	11.1 5.8	73.5 30.0	1011.1 105.2	3.3 2.2	22.0 2.0
7	4	0	0	4	0	0	4	0	0	4	2547	689	3091	1025	16419 1132	2199 205	3260 127	1128 460	15.4 5.3	12.0 5.6	75.2 44.7	1359.7 352.5	5.2 4.3	17.1 17.7

Rate of Manure Application-Annual

Trt	Rate 1997	1998	1999	2000	2001	2002	2003	2004	2005	N	Crop Harvest Fall 2005 Grain Yld.		Straw Yld.		Crop Sample N & P Analysis Grain N	Straw N	Grain P	Straw P	Soil Analysis (0-30 cm) NO_3	NH_4	P	K	Soil Analysis (30-60 cm) NO_3	NH_4
1	0	0	0	0	0	0	0	0	0	4	1349	249	1427	270	15445 1183	2089 93	3160 292	1173 339	11.3 4.6	13.6 6.3	35.0 7.6	1011.1 105.2	2.0 2.3	26.4 19.7
3	1	1	1	1	1	1	1	1	1	4	2129	433	2799	543	15579 282	2046 161	3298 144	1303 566	17.6 7.2	10.8 2.5	75.0 33.1	1423.2 237.0	3.8 4.9	25.4 18.0
6	2	2	2	2	2	2	2	2	2	4	2513	352	3335	901	17069 776	2258 270	3412 269	1075 472	18.3 9.6	11.6 1.8	95.6 48.2	1423.2 237.0	4.5 5.3	18.9 2.9
8	4	4	4	4	4	4	4	4	4	4	3856	361	5709	249	21497 2261	4615 1090	3214 183	499 175	30.8 7.0	13.2 4.1	165.4 26.1	2456.8 358.3	29.9 13.8	12.0 8.4

Rate of Manure Application-Annual & Skipped

Trt	Rate 1997	1998	1999	2000	2001	2002	2003	2004	2005	N	Crop Harvest Fall 2005 Grain Yld.		Straw Yld.		Crop Sample N & P Analysis Grain N	Straw N	Grain P	Straw P	Soil Analysis (0-30 cm) NO_3	NH_4	P	K	Soil Analysis (30-60 cm) NO_3	NH_4
1	0	0	0	0	0	0	0	0	0	4	1349	249	1427	270	15445 1183	2089 93	3160 292	1173 339	11.3 4.6	13.6 6.3	35.0 7.6	1011.1 105.2	2.0 2.3	26.4 19.7
2	1	0	0	1	0	0	0	1	0	4	1344	361	1599	421	15373 901	2210 245	3117 180	1195 319	11.4 4.6	11.6 4.4	35.1 7.9	1063.2 138.7	2.1 2.4	27.3 20.5
3	1	1	1	1	1	1	1	1	1	4	2129	433	2799	543	15579 282	2046 161	3298 144	1303 566	17.6 7.2	10.8 2.5	75.0 33.1	1423.2 237.0	3.8 4.9	25.4 18.0
4	2	0	0	2	0	0	2	0	0	4	2097	327	2648	618	15692 760	2225 196	3220 183	1271 357	17.0 8.9	11.1 5.8	73.5 30.0	1011.1 105.2	3.3 2.2	22.0 2.0
6	2	2	2	2	2	2	2	2	2	4	2513	352	3335	901	17069 776	2258 270	3432 269	1075 472	18.3 9.6	11.6 1.8	95.6 48.2	1423.2 237.0	4.5 5.3	18.9 2.9
7	4	0	0	4	0	0	4	0	0	4	2547	689	3091	1025	16419 1132	2199 205	3260 127	1128 460	15.4 5.3	12.0 5.6	75.2 44.7	1359.7 352.5	5.2 4.3	17.1 17.7
8	4	4	4	4	4	4	4	4	4	4	3856	361	5709	249	21497 2261	4615 1090	3214 183	499 175	30.8 7.0	13.2 4.1	165.4 26.1	2456.8 358.3	29.9 13.8	12.0 8.4
										LSD	533		853		1261	787	251	316	5.4	4.9	28.8	319.1	34.7	21.8

Incorporation Timing - Annual

Trt	Method	N	Crop Harvest Fall 2005 Grain Yld.		Straw Yld.		Crop Sample N & P Analysis Grain N	Straw N	Grain P	Straw P	Soil Analysis (0-30 cm) NO_3	NH_4	P	K	Soil Analysis (30-60 cm) NO_3	NH_4
1	0K0K0K0K0K0K Control with Incorp	4	1349	249	1427	270	15445 1183	2089 93	3160 292	1173 339	11.3 4.6	13.6 6.3	35.0 7.6	1011.1 105.2	2.0 2.3	26.4 19.7
3	1K1X1X 1X1X1X1X Broadcast & incorporated	4	2129	433	2799	543	15579 282	2046 161	3298 144	1303 566	17.6 7.2	10.8 2.5	75.0 33.1	1423.2 237.0	3.8 4.9	25.4 18.0
5	1K1X1X 1X1X1X1X Broadcast Delayed Incorp	4	1981	990	2317	1437	17099 2235	2413 532	3293 84	1163 621	16.1 3.3	12.1 4.8	69.8 31.4	1387.5 270.4	4.9 4.2	9.5 4.2

Source and Rate of Annual N Application-Balanced

Trt		Rate 1997	1998	1999	2000	2001	2002	2003	2004	2005	N	Crop Harvest Fall 2005 Grain Yld.		Straw Yld.		Crop Sample N & P Analysis Grain N	Straw N	Grain P	Straw P	Soil Analysis (0-30 cm) NO_3	NH_4	P	K	Soil Analysis (30-60 cm) NO_3	NH_4
1	Cntrl	0	0	0	0	0	0	0	0	0	4	1349	249	1427	270	15445 1183	2089 93	3160 292	1173 339	11.3 4.6	13.6 6.3	35.0 7.6	1011.1 105.2	2.0 2.3	26.4 19.7
3	Cattle	1	1	1	1	1	1	1	1	1	4	2129	433	2799	543	15579 282	2046 161	3298 144	1303 566	17.6 7.2	10.8 2.5	75.0 33.1	1423.2 237.0	3.8 4.9	25.4 18.0
6	Cattle	2	2	2	2	2	2	2	2	2	4	2513	352	3335	901	17069 776	2258 270	3214 183	499 175	18.3 9.6	11.6 1.8	95.6 48.2	1423.2 237.0	4.5 5.3	18.9 2.9
8	Cattle	4	4	4	4	4	4	4	4	4	4	3856	361	5709	249	21497 2261	4615 1090	3214 183	499 175	30.8 7.0	13.2 4.1	165.4 26.1	2456.8 358.3	29.9 13.8	12.0 8.4
10	Urea	1	1	1	1	1	1	1	1	1	4	3031	700	4304	856	17152 2743	2701 645	2901 113	98 101	16.2 6.1	12.7 3.3	28.6 11.7	943.5 162.0	4.9 5.2	18.6 5.7
11	Urea	2	2	2	2	2	2	2	2	2	4	3705	459	5498	415	22523 1165	5262 972	2695 343	23 12	23.7 10.9	11.2 3.9	39.7 15.9	969.5 161.7	29.5 19.4	19.6 11.3
12	Urea	4	4	4	4	4	4	4	4	4	4	3469	283	5279	865	23447 519	5445 1420	2572 220	19 9	33.1 8.9	17.4 6.7	46.6 12.2	1030.5 272.5	128.8 103.0	35.8 18.5

Alternating Cattle Manure Application

Trt	Rate 1997	1998	1999	2000	2001	2002	2003	2004	2005	N	Crop Harvest Fall 2005 Grain Yld.		Straw Yld.		Crop Sample N & P Analysis Grain N	Straw N	Grain P	Straw P	Soil Analysis (0-30 cm) NO_3	NH_4	P	K	Soil Analysis (30-60 cm) NO_3	NH_4
1	0	0	0	0	0	0	0	0	0	4	1349	249	1427	270	15445 1183	2089 93	3160 292	1173 339	11.3 4.6	13.6 6.3	35.0 7.6	1011.1 105.2	2.0 2.3	26.4 19.7
2	0	0	0	0	0	0	0	0	0	4	2097	327	2648	618	15692 760	2225 196	3220 183	1271 357	17.0 8.9	11.1 5.8	73.5 30.0	1011.1 105.2	3.3 2.2	22.0 2.0
4	2	0	0	2	0	0	2	0	0	4	2319	381	3041	677	15506 901	2175 354	3240 312	1100 242	13.5 1.9	15.1 10.3	62.4 12.8	1063.2 138.7	3.8 1.6	36.8 43.0
5	2	0	2	2	0	2	2	0	2	4	2513	652	3335	901	17069 776	2258 270	3432 269	1075 472	18.3 9.6	11.6 1.8	95.6 48.2	1423.2 237.0	4.5 5.3	18.9 2.9
6	2	2	2	2	2	2	2	2	2															
										LSD	533		853		1261	787	251	316	5.4	4.9	28.8	319.1	34.7	21.8

Note 1. Crop harvest (grain and straw yields) means in kg/ha
2. Grain and Straw Total N and Total P means in kg/ha
3. Soil Extractable (plot) NO_3, P & K means in kg/ha
4. Means in the first column are followed by standard deviations in the second column
5. N=number of observations
6. LSD (0.10) calculated at p ≤ 0.10

TABLE 3A. Melfort Swine Manure Site 2005 Yield, Soil and Crop Data

2005 Canola Crop Harvest

Manure Rate

Trt	Rate 2000	2001	2002	2003	2004	2005	N	Crop Harvest Fall 2005 Grain Yld	Straw Yld	Crop Sample N & S Analysis Grain S	Straw S	Grain N	Straw N	Soil Analysis (0-30 cm) NO3	NH4	SO4	P	K	Soil Analysis (30-60 cm) NO3	NH4
1	0	0	0	0	0	0	12	375	921	0.76	1.04	3.23	0.40	6.7	19.6	22.0	53.2	941.6	0.3	22.2
2	1	1	1	1	1	1	12	1515	3195	0.81	1.54	3.40	0.33	9.2	20.4	35.9	139.8	1043.8	1.6	21.7
3	2	0	2	0	2	0	12	1148	2194	0.84	1.46	3.11	0.40	10.1	17.9	13.0	41.4	1076.6	1.5	21.8
4	3	0	0	3	0	0	12	669	1506	0.77	1.14	3.25	0.34	9.3	20.3	16.1	43.0	908.3	0.4	20.8
5	U	U	U	U	U	U	12	875	2876	0.54	1.33	2.25	0.63	9.5	22.6	12.1	39.0	908.1	1.7	23.6
							LSD (.10)	156	306	0.07	0.53	0.19	0.09	2.1	3.1	6.8	7.6	115.7	1.0	3.5

Sulphur Application

		N	Crop Harvest Fall 2005 Grain Yld	Straw Yld	Crop Sample N & S Analysis Grain S	Straw S	Grain N	Straw N	Soil Analysis (0-30 cm) NO3	NH4	SO4	P	K	Soil Analysis (30-60 cm) NO3	NH4
1	No Sulphur Added	20	791	2241	0.64	1.08	2.80	0.55	9.5	24.6	10.2	40.9	1026.9	0.9	24.7
2	Elemental S (Tiger 90)	20	964	2161	0.82	1.57	3.34	0.34	9.4	18.1	19.7	40.8	882.9	1.0	20.4
3	Potassium Sulfate (SO4)	20	1006	1993	0.78	1.24	3.36	0.37	9.1	17.9	16.4	45.7	1018.2	1.5	21.0
		LSD (.10)	121	237	0.06	0.41	0.14	0.07	1.6	2.4	5.3	5.9	89.6	0.7	2.7

Rate of Manure X Sulfur Ammendment

Trt	Rate 2000	2001	2002	2003	2004	2005	N	Crop Harvest Fall 2005 Grain Yld	Straw Yld	Crop Sample N & S Analysis Grain S	Straw S	Grain N	Straw N	Soil Analysis (0-30 cm) NO3	NH4	SO4	P	K	Soil Analysis (30-60 cm) NO3	NH4
1	0	0	0	0	0	0														
1							No S	430	386	977	756	0.81 0.17	1.48 0.25	3.34 0.05	0.38 0.06	6.0 2.5	21.9 3.0	10.0 2.5	44.3 8.9	893.0 156.0	0.1 0.1	22.3 3.5
							Tiger 90	809	223	786	432	0.76 0.05	1.06 0.77	3.22 0.15	0.42 0.12	7.8 3.0	18.1 5.8	38.9 35.6	53.0 10.9	919.3 70.2	0.6 0.8	21.4 3.5
							SO4 S	387	189	999	271	0.72 0.05	0.80 0.25	3.15 0.12	0.42 0.10	6.5 2.7	19.0 1.3	17.1 3.0	62.3 24.8	1018.6 220.0	0.2 0.2	22.9 1.2
2	1	1	1	1	1	1														
							No S	1545	251	3413	509	0.81 0.16	0.99 0.27	3.53 0.42	0.33 0.06	9.3 2.7	26.3 11.4	9.5 3.5	36.7 11.5	1086.5 74.5	0.8 0.5	23.4 3.3
							Tiger 90	1436	454	3087	1007	0.81 0.11	2.05 0.70	3.25 0.33	0.27 0.03	7.4 2.5	18.5 5.2	15.2 4.1	31.9 10.3	910.9 216.7	1.4 1.0	21.5 4.0
							SO4 S	1516	661	3084	1105	0.81 0.22	1.57 1.19	3.41 0.61	0.38 0.19	11.1 8.6	16.4 5.0	17.1 3.9	39.1 10.7	1121.0 178.6	2.7 4.0	20.3 4.2
3	2	0	2	0	2	0														
							No S	1154	517	2414	1024	0.81 0.22	1.27 0.56	3.80 0.19	0.40 0.06	12.3 6.0	22.6 4.4	11.2 5.9	39.5 9.3	1142.1 260.7	1.3 1.4	25.0 8.0
							Tiger 90	1120	344	2198	774	0.80 0.16	1.61 0.83	3.67 0.59	0.41 0.13	8.3 4.6	18.4 4.1	14.5 2.4	39.4 6.6	1036.3 87.5	1.9 2.4	19.3 4.8
							SO4 S	1171	328	1969	413	0.83 0.07	1.51 1.52	3.65 0.20	0.39 0.08	9.8 2.6	14.9 2.1	13.3 1.1	45.4 10.7	1051.3 80.1	1.3 1.9	21.0 5.5
4	3	0	0	3	0	0														
							No S	806	326	1717	585	0.76 0.09	0.76 0.22	3.33 0.15	0.33 0.00	11.0 3.5	24.1 4.2	11.6 2.0	44.8 25.4	1045.7 237.3	0.2 0.4	24.7 2.9
							Tiger 90	635	46	1535	218	0.80 0.08	1.49 1.00	3.17 0.14	0.34 0.07	7.9 1.1	16.5 6.0	10.8 0.7	40.8 13.6	657.7 453.6	0.2 0.3	16.9 8.6
							SO4 S	593	250	1267	489	0.76 0.13	1.18 0.72	3.25 0.07	0.35 0.06	9.2 4.2	20.4 6.6	19.8 12.3	43.5 15.0	1020.7 272.9	1.0 1.0	20.9 1.9
5	U	U	U	U	U	U														
							No S	1	1	2682	1016	0.00 0.00	1.00 0.75	0 0	1.29 0.39	8.6 2.7	27.9 5.6	6.5 1.9	39.4 7.7	954.4 148.3	2.0 1.9	27.9 8.5
							Tiger 90	1322	99	3298	221	0.83 0.13	1.86 0.99	3.41 0.17	0.31 0.02	10.7 3.0	20.9 5.5	13.1 3.5	39.1 8.5	890.4 33.1	1.1 1.3	22.7 7.7
							SO4 S	1301	193	2647	487	0.79 0.04	1.35 0.36	3.30 0.10	0.38 0.02	8.9 1.4	18.9 2.9	14.6 1.9	38.4 3.9	879.6 166.5	2.2 1.0	20.1 6.3

Manure Rate - No Sulphur Ammendment

Trt	Rate 2000	2001	2002	2003	2004	2005	N	Crop Harvest Fall 2005 Grain Yld	Straw Yld	Crop Sample N & S Analysis Grain S	Straw S	Grain N	Straw N	Soil Analysis (0-30 cm) NO3	NH4	SO4	P	K	Soil Analysis (30-60 cm) NO3	NH4
1	0	0	0	0	0	0	4	430	386	0.81 0.17	1.48 0.25	3.34 0.05	0.38 0.06	6.0 2.5	21.9 3.0	10.0 2.5	44.3 8.9	893.0 156.0	0.1 0.1	22.3 3.5
2	1	1	1	1	1	1	4	1545	251	0.81 0.16	0.99 0.27	3.53 0.42	0.33 0.06	9.3 2.7	26.3 11.4	9.5 3.5	36.7 11.5	1086.5 74.5	0.8 0.5	23.4 3.3
3	2	0	2	0	2	0	4	1154	517	0.81 0.22	1.27 0.56	3.80 0.19	0.40 0.06	12.3 6.0	22.6 4.4	11.2 5.9	39.5 9.3	1142.1 260.7	1.3 1.4	25.0 8.0
4	3	0	0	3	0	0	4	806	326	0.76 0.09	0.76 0.22	3.33 0.15	0.33 0.00	11.0 3.5	24.1 4.2	11.6 2.0	44.8 25.4	1045.7 237.3	0.2 0.4	24.7 2.9
5	U	U	U	U	U	U	4	0.5	0.6	0.00 0.00	1.00 0.75	0.00 0.00	1.29 0.39	8.8 2.7	27.9 5.6	8.6 1.9	39.4 7.7	954.4 148.3	2.0 1.9	27.9 8.5
							LSD (.10)	293	579	0.17	0.53	0.25	0.22	2.8	9.5	3.3	13.0	172.3	1.4	7.2

Manure Rate - Elemental Sulphur T 90 Ammendment

Trt	Rate 2000	2001	2002	2003	2004	2005	N	Crop Harvest Fall 2005 Grain Yld	Straw Yld	Crop Sample N & S Analysis Grain S	Straw S	Grain N	Straw N	Soil Analysis (0-30 cm) NO3	NH4	SO4	P	K	Soil Analysis (30-60 cm) NO3	NH4
1	0	0	0	0	0	0	4	809	223	0.76 0.05	1.06 0.77	3.22 0.15	0.40 0.12	7.8 3.0	18.1 5.8	38.9 35.6	53.0 10.9	919.3 70.2	0.6 0.8	21.4 3.5
2	1	1	1	1	1	1	4	1436	454	0.81 0.11	2.05 0.70	3.25 0.33	0.27 0.03	7.4 2.5	18.5 5.2	15.2 4.1	31.9 10.3	910.9 216.7	1.4 1.0	21.5 4.0
3	2	0	2	0	2	0	4	1516	344	0.80 0.16	1.61 0.83	3.67 0.59	0.41 0.13	9.3 4.6	16.4 4.1	14.5 2.4	39.4 6.6	1036.3 87.5	1.9 2.4	19.3 4.8
4	3	0	0	3	0	0	4	635	46	0.80 0.08	1.49 1.00	3.17 0.14	0.34 0.07	7.9 1.1	16.5 6.0	16.8 0.7	40.8 13.6	657.7 453.6	0.2 0.3	16.9 8.6
5	U	U	U	U	U	U	4	1322	99	0.83 0.13	1.86 0.99	3.41 0.17	0.31 0.02	10.7 3.0	20.9 5.5	13.1 3.5	39.1 8.5	890.4 33.1	1.1 1.3	22.7 7.7
							LSD (.10)	258	552	0.11	1.01	0.35	0.11	3.6	4.8	19.8	13.1	266.4	1.7	6.4

Manure Rate - Potassium Sulphate Ammendment

Trt	Rate 2000	2001	2002	2003	2004	2005	N	Crop Harvest Fall 2005 Grain Yld	Straw Yld	Crop Sample N & S Analysis Grain S	Straw S	Grain N	Straw N	Soil Analysis (0-30 cm) NO3	NH4	SO4	P	K	Soil Analysis (30-60 cm) NO3	NH4
1	0	0	0	0	0	0	4	367	189	0.72 0.05	0.60 0.25	3.15 0.12	0.42 0.10	6.5 2.7	19.0 1.3	17.1 3.0	62.3 24.8	1018.6 220.0	0.2 0.2	22.9 1.2
2	1	1	1	1	1	1	4	1516	661	0.81 0.22	1.57 1.19	3.41 0.61	0.38 0.19	11.1 8.6	16.4 5.0	17.1 3.9	39.1 10.7	1121.0 178.6	2.7 4.0	20.3 4.2
3	2	0	2	0	2	0	4	1127	228	0.83 0.07	1.51 1.52	3.65 0.20	0.39 0.08	9.8 2.6	14.9 2.1	13.3 1.1	45.4 10.7	1051.3 80.1	1.3 1.9	21.0 5.5
4	3	0	0	3	0	0	4	593	250	0.76 0.13	1.18 0.72	3.25 0.07	0.35 0.06	9.2 4.2	20.4 6.6	19.8 12.3	43.5 15.0	1020.7 272.9	1.0 1.0	20.9 1.9
5	U	U	U	U	U	U	4	1301	193	0.79 0.04	1.35 0.36	3.30 0.10	0.38 0.02	8.9 1.4	18.9 2.9	14.6 1.9	38.4 3.9	879.6 166.5	2.2 1.0	20.1 6.3
							LSD (.10)	329	547	0.12	1.21	0.41	0.14	4.9	5.6	7.6	15.6	183.3	2.1	5.2

Note: 1 Crop Harvest (grain and straw yields) means in kg/ha
2 Grain and Straw N and S means in per cent (%)
3 Soil Extractable Nitrate NO3 SO4 P & K means in kg/ha
4 Means in the first column are followed by standard deviations in the second column
5 N=Number of observations
6 LSD (0.10) calculated at p ≤ 0.10

Table 3A (continued). Melfort Swine Manure Site 2005 Results

2005 Canola Crop Harvest

Manure Rate

Trt	Rate 2000	2001	2002	2003	2004	2005	N	Grain Yld	Straw Yld	Grain S	Straw S	Grain N	Straw N
								Crop Harvest Fall 2005		**Crop Samole N & S Analysis**			
1	0	0	0	0	0	0	12	375	511	0.78	1.04	3.23	0.40
2	1	1	1	1	1	1	12	1519	3195	0.81	1.54	3.40	0.33
3	2	0	2	0	2	0	12	1148	2194	0.84	1.46	3.71	0.40
4	3	0	0	3	0	0	12	685	1506	0.77	1.14	3.25	0.34
5	U	U	U	U	U	U	12	875	2676	0.54	1.33	2.25	0.63
							LSD (.10)	156	306	0.07	0.53	0.19	0.09

Manure Rate - No Sulphur Ammendment

Trt	Rate 2000	2001	2002	2003	2004	2005	N	Grain Yld	Straw Yld.	Grain S	Straw S	Grain N	Straw N
										Crop Samole N & S Analysis			
1	0	0	0	0	0	0	4	430 386	977 756	0.81 0.17	1.48 0.25	3.34 0.06	0.38 0.06
2	1	1	1	1	1	1	4	1545 251	3413 509	0.81 0.16	0.99 0.27	3.53 0.42	0.33 0.06
3	2	0	2	0	2	0	4	1154 517	2414 1024	0.81 0.22	1.27 0.56	3.80 0.19	0.40 0.06
4	3	0	0	3	0	0	4	826 326	1717 585	0.76 0.09	0.76 0.22	3.33 0.15	0.33 0.00
5	U	U	U	U	U	U	4	0 5 0 6	2682 1036	0.00 0.00	1.00 0.75	0.00 0.00	1.29 0.39
							LSD (.10)	293	579	0.17	0.53	0.25	0.22

Manure Rate - Elemental Sulphur T-90 Ammendment

Trt	Rate 2000	2001	2002	2003	2004	2005	N	Grain Yld	Straw Yld	Grain S	Straw S	Grain N	Straw N
1	0	0	0	0	0	0	4	309 223	786 432	0.76 0.05	1.06 0.77	3.22 0.15	0.40 0.12
2	1	1	1	1	1	1	4	1436 454	3087 1007	0.81 0.11	2.06 0.70	3.25 0.33	0.27 0.03
3	2	0	2	0	2	0	4	1120 344	2198 774	0.80 0.16	1.61 0.83	3.67 0.59	0.41 0.13
4	3	0	0	3	0	0	4	635 46	1535 218	0.80 0.08	1.49 1.00	3.17 0.14	0.34 0.07
5	U	U	U	U	U	U	4	1322 99	3296 221	0.83 0.13	1.66 0.99	3.41 0.17	0.31 0.02
							LSD (.10)	253	552	0.11	1.01	0.35	0.11

Manure Rate - Potassium Sulphate Ammendment

Trt	Rate 2000	2001	2002	2003	2004	2005	N	Grain Yld	Straw Yld	Grain S	Straw S	Grain N	Straw N
1	0	0	0	0	0	0	4	387 189	999 271	0.72 0.05	0.60 0.25	3.15 0.12	0.42 0.10
2	1	1	1	1	1	1	4	1576 661	3084 1105	0.81 0.22	1.57 1.19	3.41 0.61	0.38 0.19
3	2	0	2	0	2	0	4	1171 228	1969 413	0.83 0.07	1.51 1.52	3.65 0.20	0.39 0.08
4	3	0	0	3	0	0	4	593 250	1267 489	0.76 0.13	1.18 0.72	3.25 0.07	0.35 0.06
5	U	U	U	U	U	U	4	1301 193	2647 487	0.79 0.04	1.35 0.38	3.38 0.10	0.28 0.02
							LSD (.10)	309	547	0.12	1.21	0.41	0.14

Sulphur Application

		N	Grain Yld	Straw Yld	Grain S	Straw S	Grain N	Straw N
1	No Sulphur Added	20	751	1741	0.64	1.74	3.38	0.48
2	Elemental S (Tiger 90)	20	1010	2181	0.80	1.47	3.58	0.36
3	Potassium Sulphate (K2SO4)	20	1006	1993	0.78	0.94	3.36	0.37
		LSD (.10)	121	237	0.06	0.41	0.14	0.07

Rate of Manure X Sulfur Ammendment

Rate 2000	2001	2002	2003	2004	2005		N	Grain Yld	Straw Yld	Grain S	Straw S	Grain N	Straw N
1	0	0	0	0	0	1	No S	4	430 386	977 756	0.81 0.17	1.48 0.25	3.34 0.06	0.38 0.06
						2	Tiger 90	4	309 223	786 432	0.76 0.05	1.06 0.77	3.22 0.15	0.40 0.12
						3	SO_4 S	4	387 189	999 271	0.72 0.05	0.60 0.25	3.15 0.12	0.42 0.10
2	1	1	1	1	1			N						
						1	No S	4	1545 251	3413 509	0.81 0.16	0.99 0.27	3.53 0.42	0.33 0.06
						2	Tiger 90	4	1436 454	3087 1007	0.81 0.11	2.06 0.70	3.25 0.33	0.27 0.03
						3	SO_4 S	4	1576 661	3084 1105	0.81 0.22	1.57 1.19	3.41 0.61	0.38 0.19
3	2	0	2	0	2			N						
						1	No S	4	1154 517	2414 1024	0.81 0.22	1.27 0.56	3.80 0.19	0.40 0.06
						2	Tiger 90	4	1120 344	2198 774	0.80 0.16	1.61 0.83	3.67 0.59	0.41 0.13
						3	SO_4 S	4	1171 228	1969 413	0.83 0.07	1.51 1.52	3.65 0.20	0.39 0.08
4	3	0	0	3	0	0		N						
						1	No S	4	826 326	1717 585	0.76 0.09	0.76 0.22	3.33 0.15	0.33 0.00
						2	Tiger 90	4	635 46	1535 218	0.80 0.08	1.49 1.00	3.17 0.14	0.34 0.07
						3	SO_4 S	4	593 250	1267 489	0.76 0.13	1.18 0.72	3.25 0.07	0.35 0.06
5	U	U	U	U	U	U		N						
						1	No S	4	1 1	2682 1036	0.00 0.00	1.00 0.75	0 0	1.29 0.39
						2	Tiger 90	4	1322 99	3296 221	0.83 0.13	1.66 0.99	3.41 0.17	0.31 0.02
						3	SO_4 S	4	1301 193	2647 487	0.79 0.04	1.35 0.38	3.38 0.10	0.28 0.02

Note 1. Crop harvest (grain and straw) means in kg/ha
2. Carbon, nitrogen, and sulfur means in percent (%)
3. Means in the first column are followed by Std deviations in the second column
4. N=Number of observations
5. LSD (0.10) calculated at p ≤ 0.10

TABLE 4A. Plenty Swine Manure Site 2005 Yield, Crop and Soil Nutrients

2005 Wheat Crop Harvest

Regime	1999	2000	2001	2002	2003	2004	2005	N	Crop Harvest Fall 2005 Grain Yld.	Crop Harvest Fall 2005 Straw Yld.	Grain N & P Analysis Total P	Grain N & P Analysis Total N	Straw N & P Analysis Total P	Straw N & P Analysis Total N	Soil Analysis (0-30 cm) NO_3	Soil Analysis (0-30 cm) NH_4	Soil Analysis (0-30 cm) P	Soil Analysis (0-30 cm) K	Soil Analysis (30-60 cm) NO_3	Soil Analysis (30-60 cm) NH_4
1	X	O	O	O	O	O	O	15	2244	2313	3124	19599	80	3012						
2	X	O	O	X	O	O	X	15	2274	2507	2796	22966	45	3805						
3	X	O	X	O	X	O	X	15	2486	2964	2976	24469	53	3853						
4	X	X	O	O	X	X	O	15	2481	3086	3139	23917	32	3829						
5	X	X	X	O	O	X	O	15	2513	2921	3072	25006	115	3537	65.4	24.2	44.4	1459.2	149.9	56.6
6	X	X	X	X	X	X	X	15	2366	2650	3645	26132	119	3409	62.8	22.4	65.9	1970.5	201.5	20.2
								LSD (.10)	273	385	237	852	27	411	36.0	4.0	8.4	151.9	116.1	13.1

Source		N	Grain Yld.	Straw Yld.	Total P	Total N	Total P	Total N	N						
1	Check	18	1177	1200	3774	21405	171	3140	6	12.5	31.3	42.8	1508.9	3.9	39.4
2	Low Hog Manure 37 000 L ha^{-1}	18	3000	3516	2943	25676	49	3969	6	86.9	22.6	66.4	1870.9	265.3	53.4
3	High Hog Manure 74 000 L ha^{-1}	18	3266	3853	2936	26457	53	4545	6	169.9	20.5	84.0	1938.3	580.7	46.6
4	Low Fertilizer 40 kg N ha^{-1}	18	2174	2406	3131	21850	52	3115	6	15.5	22.4	40.7	1603.3	6.9	23.0
5	High Fertilizer 80 kg N ha^{-1}	18	2416	2735	2843	23019	44	3102	6	35.6	19.7	42.0	1652.9	22.5	29.8
		LSD (.10)	250	351	216	778	25	375		57.0	6.3	13.2	240.2	188.3	20.8

Effect of Source within Regime

		N	Grain Yld.		Straw Yld.		Total P		Total N		Total P		Total N	
1	X O O O O O O													
	1 Check	3	1184	18	1106	56	3342	39	18574	1547	316	66	2801	414
	2 Low Hog Manure 37 000 L ha^{-1}	3	2694	440	2946	457	2755	207	19360	1231	20	3	2758	484
	3 High Hog Manure 74 000 L ha^{-1}	3	3572	625	3808	954	2674	506	23065	586	30	32	4310	1059
	4 Low Fertilizer 40 kg N ha^{-1}	3	1898	99	1825	388	3340	278	19419	2787	15	18	2902	709
	5 High Fertilizer 80 kg N ha^{-1}	3	1870	104	1880	406	3507	421	17576	717	17	10	2287	285
		LSD (.10)	576		892		475		2641		49		959	
2	X O O X O O X													
	1 Check	3	1167	422	1183	305	3193	128	20172	1156	117	141	3162	333
	2 Low Hog Manure 37 000 L ha^{-1}	3	2961	600	3262	867	2850	284	26272	1310	12	12	4319	739
	3 High Hog Manure 74 000 L ha^{-1}	3	3004	292	3676	1095	2387	291	25358	2433	44	73	5397	1716
	4 Low Fertilizer 40 kg N ha^{-1}	3	1757	513	1750	504	3202	399	21327	1343	36	34	2980	179
	5 High Fertilizer 80 kg N ha^{-1}	3	2481	492	2666	881	2351	537	21700	2415	14	8	3189	769
		LSD (.10)	763		1015		604		2524		101		1402	

		N	Crop Harvest Fall 2005 Grain Yld.		Crop Harvest Fall 2005 Straw Yld.		Grain N & P Analysis Total P		Grain N & P Analysis Total N		Straw N & P Analysis Total P		Straw N & P Analysis Total N		Soil Analysis NO_3	Soil Analysis NH_4	Soil Analysis P	Soil Analysis K	Soil Analysis (30-60 cm) NO_3	Soil Analysis (30-60 cm) NH_4	
3	X O X O X O X																				
	1 Check	3	1007	67	1090	65	3638	745	21818	1429	211	139	3720	284							
	2 Low Hog Manure 37 000 L ha^{-1}	3	3265	464	3839	543	2738	471	27169	2040	19	13	4652	335							
	3 High Hog Manure 74 000 L ha^{-1}	3	3390	226	4377	571	2965	106	27745	756	21	12	4601	330							
	4 Low Fertilizer 40 kg N ha^{-1}	3	2278	762	2405	930	2820	928	21113	737	8	5	2750	189							
	5 High Fertilizer 80 kg N ha^{-1}	3	2469	312	3108	652	2718	855	24498	1288	6	5	3540	422							
		LSD (.10)	733		962		939		1522		98		619								
4	X X O O X X O																				
	1 Check	3	1265	227	1212	135	4096	190	21035	1596	84	94	2924	477							
	2 Low Hog Manure 37 000 L ha^{-1}	3	3416	402	4265	993	2974	233	25928	1332	12	9	4361	658							
	3 High Hog Manure 74 000 L ha^{-1}	3	3352	704	4252	1135	3043	563	26829	3092	21	7	4474	419							
	4 Low Fertilizer 40 kg N ha^{-1}	3	2107	376	2540	535	2889	379	21963	521	21	9	3442	554							
	5 High Fertilizer 80 kg N ha^{-1}	3	2762	175	3211	239	2694	274	23828	553	23	7	3946	784							
		LSD (.10)	615		1076		540		2780		69		951								
5	X X X O O X O																				
	1 Check	3	1411	189	1579	340	3746	426	23050	1632	142	12	3181	794	10.4	4.1	33.7	7.4	37.1	6.0	1371.5	220.8	4.3	3.0	45.9	18.2
	2 Low Hog Manure 37 000 L ha^{-1}	3	2734	353	3460	421	2885	191	27426	608	117	10	3815	476	99.1	49.2	20.7	5.3	52.7	11.4	1633.1	197.0	114.5	67.7	72.6	36.7
	3 High Hog Manure 74 000 L ha^{-1}	3	3703	434	4177	508	3124	35	26979	1086	87	55	4297	423	166.9	107.5	22.4	3.2	71.3	9.6	1713.6	227.0	601.5	219.8	70.6	1.0
	4 Low Fertilizer 40 kg N ha^{-1}	3	2304	667	2760	908	3108	328	22982	481	121	10	3347	1068	10.3	1.5	24.0	9.4	31.6	1.3	1242.5	45.9	10.1	12.8	40.8	9.5
	5 High Fertilizer 80 kg N ha^{-1}	3	2416	344	2631	569	2496	205	24594	491	107	7	3046	511	40.3	33.4	20.2	3.4	29.4	4.5	1335.5	131.4	19.2	13.9	54.1	20.1
		LSD (.10)	615		948		368		1506		41		988		84.0		9.3		9.0		283.2		162.9		30.9	
6	X X X X X X X																				
	1 Check	3	1025	247	1028	344									14.5	0.9			48.4	7.7	1648.4	70.3	3.5	3.6		
	2 Low Hog Manure 37 000 L ha^{-1}	3	2909	288	3325	361									24.8	66.7			80.1	26.6	2108.8	338.0	416.0	399.2		
	3 High Hog Manure 74 000 L ha^{-1}	3	2697	637	2827	370									172.9	108.5			96.7	38.3	2163.1	442.9	560.0	487.8		
	4 Low Fertilizer 40 kg N ha^{-1}	3	2702	655	3155	913									20.7	5.3			49.8	16.1	1964.1	511.8	1.8	3.2		
	5 High Fertilizer 80 kg N ha^{-1}	3	2499	498	2915	713									30.9	7.1			58.5	10.5	1970.3	506.6	25.5	44.8		
		LSD (.10)	743		804										87.7				26.7		426.2		366.8			

Note 1. Crop harvest (grain and straw yields) means in kg ha^{-1}
2. Grain and Straw Total N and Total P means in kg ha^{-1}
3. Soil Extractable NH4 NO3 P & K means in kg ha^{-1}
4. Means in the first column are followed by standard deviations in the second column
5. For fall 2005 only Regimes 5 and 6 were soil sampled at depths 0-30 and 30-60 cm
6. N=number of observations
7. LSD (.10) calculated at p ≤ 0.10

TABLE 5A. Riverhurst Swine Manure Site 2005 Yield, Crop and Soil Nutrients

2005 Canola Crop Harvest

Regime	1999	2000	2001	2002	2003	2004	2005	N	Crop Harvest Fall 2005 Grain Yld	Crop Harvest Fall 2005 Straw Yld	Grain N & P Analysis Total P	Grain N & P Analysis Total N	Straw N & P Analysis Total P	Straw N & P Analysis Total N	Soil Analysis (0-30 cm) NO_3	Soil Analysis (0-30 cm) NH_4	Soil Analysis (0-30 cm) P	Soil Analysis (0-30 cm) K	Soil Analysis (30-60 cm) NO_3	Soil Analysis (30-60 cm) NH_4
5	X	X	X	O	O	X	O	15	2618	6658	6940	32700	220	5462	25.2	7.2	33.5	432.5	31.2	4.3
6	X	X	X	X	X	X	X	15	2634	5918	7268	35666	401	7178	35.7	9.0	37.8	380.0	65.6	3.6
								LSD	267	437	227	690	119	894	11.1	1.9	9.5	65.2	43.6	1.2

Source			N	Grain Yld	Straw Yld	N	Total P	Total N	Total P	Total N	N							
1	Check		18	2898	6008	6	6942	30962	27	2813	6	12.6	7.2	18.9	371.5	5.2	5.3	
2	Low Hog Manure	37 000 L ha^{-1}	18	2877	6976	6	7167	36350	490	8439	6	37.3	8.8	42.7	440.1	60.0	4.3	
3	High Hog Manure	74 000 L ha^{-1}	18	2600	6477	6	7635	36800	887	10628	6	59.2	9.2	75.4	506.1	143.6	3.9	
4	Low Fertilizer	40 kg N ha^{-1}	18	2496	5311	6	6899	32568	43	3924	6	22.1	7.7	20.7	400.5	11.1	3.5	
5	High Fertilizer	80 kg N ha^{-1}	18	2958	6671	6	6877	34235	106	5841	6	21.0	7.3	20.5	313.1	18.7	4.3	
			LSD	423	690		359	1091	188	1413		17.6	3.1	15.1	103.2	69.3	1.9	

Effect of Source within Regime			N	Grain Yld		Straw Yld		Total P		Total N		Total P		Total N									
5	X	X	X	O	O	X	O																
1	Check		3	2779	300	6334	393	6718	46	28973	1098	18	2	2277	340	12.6	5.2	7.7	2.0	16.6	4.7	395.5	48.3	9.5	2.4	4.4	2.3
2	Low Hog Manure	37 000 L ha^{-1}	3	2900	320	7096	435	6787	297	34940	795	187	169	7105	398	23.1	5.5	5.9	1.4	33.2	3.1	463.6	42.4	31.6	19.6	3.8	3.3
3	High Hog Manure	74 000 L ha^{-1}	3	2760	603	6696	1299	7478	262	35490	494	819	184	10138	712	50.3	6.5	7.9	1.6	74.8	7.3	456.8	45.3	97.4	70.5	3.8	3.5
4	Low Fertilizer	40 kg N ha^{-1}	3	2550	409	6200	362	6988	315	31076	1753	30	41	3114	1251	21.2	19.0	6.8	1.5	20.4	6.2	444.3	97.5	9.1	2.9	4.9	3.6
5	High Fertilizer	80 kg N ha^{-1}	3	3101	562	6962	1245	6727	239	33020	892	43	62	4726	867	18.8	4.5	7.5	3.2	22.4	9.3	402.4	52.6	11.6	10.4	4.5	2.7
			LSD	697		1369		332		1188		196		892		12.1		2.0		1.9		1.9		49.5		3.2	
6	X	X	X	X	X	X	X																
1	Check		3	2617	269	5677	410	7165	335	32950	1804	35	18	3349	495	12.5	0.8	6.8	3.1	21.1	4.7	347.5	37.6	6.5	3.5	2.2	2.0
2	Low Hog Manure	37 000 L ha^{-1}	3	2854	244	6856	146	7546	660	37760	291	794	445	9772	1901	51.5	7.0	11.8	5.5	52.3	11.9	416.7	39.7	88.1	20.1	4.9	4.7
3	High Hog Manure	74 000 L ha^{-1}	3	2440	292	6257	33	7792	563	38110	992	955	13	11117	978	68.1	49.9	10.8	2.1	75.9	40.4	555.3	174.7	194.3	202.6	4.1	3.5
4	Low Fertilizer	40 kg N ha^{-1}	3	2442	754	4421	520	6810	266	34060	819	55	34	4735	2064	23.0	8.5	8.7	4.1	21.1	4.2	356.7	46.6	13.2	6.7	2.2	2.6
5	High Fertilizer	80 kg N ha^{-1}	3	2442	754	4421	520	7026	156	35450	1582	169	207	6906	2772	23.3	5.7	7.2	3.8	18.6	4.7	223.7	197.1	25.6	28.0	4.8	1.3
			LSD	570		538		688		1997		349		2875		35.4		6.2		31.0		203.2		139.0		2.9	

Note 1. Crop harvest (grain and straw yields) means in kg ha^{-1}
2. Grain and Straw Total N and Total P means in kg ha
3. Soil Extractable NH_4, NO_3, P & K means in kg ha
4. Means in the first column are followed by standard deviations in the second column
5. For Fall 2005 only Regimes 5 and 6 were soil sampled at depths 0-30 and 30-60 cm
6. For Fall 2005 only Regimes 5 and 6 were crop sampled for harvest
7. N=Number of observations
8. LSD (0.10) calculated at p ≤ 0.10

Table 6A SUMMARY ALL SITES 2005 Results Crop Yield, Plant and Soil Nutrients Summary

Sites: Dixon Swine, Dixon Cattle, Melfort, Plenty, Riverhurst Irrigated, SK.

Dixon Hog Manure Site

Rate of Manure Application

Trt	Rate 1997	1998	1999	2000	2001	2002	2003	2004	2005
2	0	0	0	0	0	0	0	0	0
4	1	1	1	1	1	1	1	1	1
7	2	2	2	2	2	2	2	2	2
9	4	4	4	4	4	4	4	4	4
12	1 BAI	1 BAI	1 BAI	1 BAI	1 BAI	1 BAI	1 BAI	1 BAI	1 BAI
14	U2	U2	U2	U2	U2	U2	U2	U2	U2

N	Crop Harvest Fall 2005 Grain Yld		Straw Yld		Crop Sample N & P Analysis Grain N		Straw N		Grain P		Straw P		Soil Analysis (0-30 cm) NO3		NH4		P		K		SO4		Soil Analysis (30-60 cm) NO3		NH4	
4	1089	183	1188	247	15313	627	2307	196	2396	292	732	551	8.9	2.0	11.9	5.4	30.7	7.4	663.1	222.7			2.3	1.0	13.3	9.3
4	3360	258	4854	330	18800	2442	3731	1109	2641	322	62	63	16.4	6.7	15.4	9.4	25.7	3.3	1050.1	200.3			8.5	4.8	16.0	6.5
4	3755	556	5260	1016	22401	936	5800	737	2481	144	37	49	23.3	11.2	14.5	7.6	32.4	14.3	1336.7	256.4			15.9	13.6	32.5	3.0
4	4082	831	6368	1462	23806	1070	6968	880	2886	225	31	24	33.8	20.4	16.1	8.9	53.8	29.6	1511.4	223.6			209.0	164.5	37.0	5.1
4	4082	831	6368	1462	23806	1070	6968	880	2886	225	31	24	33.8	20.4	16.1	8.9	53.8	29.6	1511.4	223.6			3.4	1.3	16.3	0.2
4	2444	836	3396	918	15729	99	3104	217	2964	281	131	156	12.9	0.7	28.0	6.1	27.0	0.1	1140.3	270.6			44.7	32.6	21.9	8.2
4	2725	285	4216	815	21553	1364	4192	752	2110	393	18	11	14.9	3.2	17.2	8.0	22.7	2.6	738.0	236						
LSD --		589		930		1304		826		392		420		7.1		9.7		12.3		220.7				55.5		20.1

Dixon Cattle Manure Site

Rate of Manure Application

Trt	Rate 1997	1998	1999	2000	2001	2002	2003	2004	2005
1	0	0	0	0	0	0	0	0	0
3	1	1	1	1	1	1	1	1	1
6	2	2	2	2	2	2	2	2	2
8	4	4	4	4	4	4	4	4	4
11	U2	U2	U2	U2	U2	U2	U2	U2	U2

N	Grain Yld		Straw Yld		Grain N		Straw N		Grain P		Straw P		NO3		NH4		P		K		SO4		NO3		NH4	
4	1349	249	1627	270	15445	1183	2069	93	3180	292	1173	339	11.3	4.6	13.8	6.3	35.0	7.5	1011.1	105.2			2.9	2.3	28.4	19.7
4	2129	433	2798	543	19578	282	2046	161	3288	144	1303	586	17.6	7.2	10.8	2.5	75.0	33.1	1423.2	237.0			3.8	4.9	25.4	18.0
4	2513	352	3338	901	17069	776	2258	270	3432	288	1075	472	18.3	9.6	11.8	1.8	95.6	48.2	1423.2	237.2			4.5	5.3	18.9	2.9
4	2806	361	3709	240	21497	2261	4815	1880	3214	193	490	175	20.8	7.0	13.2	4.1	165.4	26.1	2456.8	358.3			29.9	13.8	12.0	8.4
4	3705	450	5408	415	22533	1185	5262	972	2695	343	23	12	23.7	10.9	11.2	3.9	19.7	15.9	969.5	161.1			29.5	19.4	19.6	11.3
LSD --		533		853		1761		787		251		316		5.4		4.9		28.8		319.1				34.7		21.8

Melfort Hog Manure Site

Rate of Manure Application

Trt	Rate (lbs Sulfur) 2000	2001	2002	2003	2004	2005
1	0	0	0	0	0	0
2	1	1	1	1	1	1
3	2	0	2	0	2	0
4	3	0	0	3	0	0
5	U	U	U	U	U	U

N	Grain Yld		Straw Yld		Grain S		Straw S		Grain N		Straw N															
4	430	386	977	756	0.81	0.17	1.49	0.25	3.34	0.05	0.39	0.36	8.0	2.5	21.9	3.9	44.3	8.9	893.0	156.0	10.0	2.5	0.1	0.1	22.3	3.5
4	1545	291	3413	509	0.81	0.18	0.99	0.27	3.53	0.42	0.33	0.06	9.3	2.7	28.3	11.4	36.7	11.5	1099.5	74.5	9.5	3.5	0.8	0.5	23.4	3.3
4	1154	517	2414	1024	0.81	0.22	1.27	0.56	3.80	0.19	0.40	0.06	12.3	6.0	22.8	4.4	39.5	9.3	1142.1	260.7	11.2	5.9	1.3	1.4	25.0	8.0
4	826	326	1717	985	0.76	0.09	0.78	0.23	3.33	0.15	0.33	0.00	11.0	3.5	24.1	4.2	44.6	25.4	1045.7	237.3	11.6	2.0	0.2	0.4	24.7	2.9
4	0.5	0.6	2682	1036	0.90	0.00	1.00	0.79	0.00	0.00	1.28	0.39	8.8	2.7	27.9	5.6	39.4	7.7	954.4	148.3	8.6	1.9	2.0	1.9	27.9	8.5
LSD --		293		579		0.17		0.53		0.25		0.22		2.8		6.5		13.0		172.3		3.3		1.4		7.2

Plenty Hog Manure Site

Rate of Manure Application

Regime 6

Trt	Rate 1999	2000	2001	2002	2003	2004	2005
1	0	0	0	0	0	0	0
2	1	1	1	1	1	1	1
3	2	2	2	2	2	2	2
4	U1	U1	U1	U1	U1	U1	U1
5	U2	U2	U2	U2	U2	U2	U2

N	Grain Yld		Straw Yld		Grain N		Straw N		Grain P		Straw P															
3	1025	247	1028	344	23782	1211	3081	341	4633	263	159	13	14.5	0.9			48.4	7.7	1646.4	70.3			3.5	3.6		
3	2809	268	3325	381	27800	242	3909	286	3454	298	114	2	74.8	66.7			80.1	28.6	2108.8	338.0			416.0	399.2		
3	2497	637	2827	370	28784	364	4190	784	3422	437	115	9	172.9	108.5			96.1	38.3	2163.1	440.9			560.0	487.6		
3	2702	650	3135	913	24296	868	3273	985	3427	213	110	8	29.7	9.3			49.8	19.1	1954.1	511.8			1.8	3.2		
3	2499	490	2915	713	25920	382	2622	186	5292	127	99	2	30.9	7.1			54.5	10.5	1970.3	536.6			25.9	44.8		
LSD --		741		804		1052		1040		403		13		87.7				26.7		426.2				396.6		

Riverhurst Irrigated Hog Manure Site

Rate of Manure Application

Regime 6

Trt	Rate 1999	2000	2001	2002	2003	2004	2005
1	0	0	0	0	0	0	0
2	1	1	1	1	1	1	1
3	2	2	2	2	2	2	2
4	U1	U1	U1	U1	U1	U1	U1
5	U2	U2	U2	U2	U2	U2	U2

N	Grain Yld		Straw Yld		Grain N		Straw N		Grain P		Straw P															
3	2617	289	5677	430	37960	1804	3349	496	7165	335	35	18	12.9	0.8	6.8	2.1	21.1	4.7	347.5	31.6			6.6	3.5	2.2	2.9
3	2854	244	6056	146	37780	291	9772	1901	7548	940	784	445	51.5	7.0	11.8	2.5	52.3	31.9	416.7	39.7			98.1	20.1	4.9	4.7
3	2440	292	6757	35	38110	992	11117	979	7792	563	958	13	68.1	49.9	10.6	2.1	75.9	46.4	556.3	174.7			194.5	202.8	4.1	3.5
3	2442	754	4421	570	34060	819	4735	2064	6610	268	56	34	23.0	8.5	8.7	4.1	21.1	4.2	356.7	48.6			13.2	6.7	2.2	2.6
3	2615	234	6179	418	35450	1882	6906	2772	7026	156	169	207	23.3	9.7	7.2	3.8	18.6	4.7	223.7	197.1			25.8	28.0	4.8	1.3
LSD --		570		536		1897		2875		686		349		35.4		9.2		31.0		203.2				139.0		2.6

Note 1 Crop harvest (grain and straw yields) means in kg ha⁻¹

2 Grain and Straw N and S means in per cent (%)

3 Grain and Straw Total N and Total P means in kg ha⁻¹

4 Soil Extractable NH4 NO3 SO4 P & K means in kg ha⁻¹

5 Means on the first column are followed by Standard deviations in the second column

6 N=Number of observations

7 LSD (0.10) calculated at p ≤ 0.10

2006 FIELD SEASON

(Complete tabular presentation of results and statistical analysis in Tables 1B-5B at the end of the 2006 field season discussion)

Dixon Swine Manure Experiment 2006 (Table 1B)

As in 2005, the grain and straw yield of the crop (flax) grown at the Dixon site in 2006 responded strongly to manure addition (Figure 6).

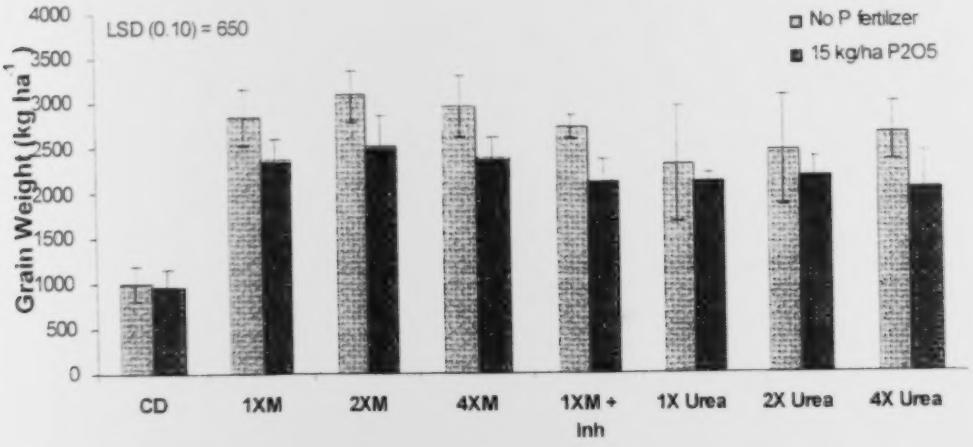


Figure 6. Flax seed yields for swine manure and urea fertilizer treatments with and without supplemental phosphorus fertilizer at 2006 Dixon field site.

* Inhibitor = 0.275 ml kg^{-1} of Super N Concentrate added to swine manure before application.

** Supplemental phosphorus banded into soil at a rate of 15 kg ha^{-1} annually.

The 1X annual addition treatment produced flax grain yields of ~ 2700 kg/ha that were nearly three times that of the unfertilized control and significantly higher than the urea and urea + P fertilizer treatments. These results support previous observations that an annual application rate of 3000 to 4000 gallons per acre per year (~ 100 kg N/ha) is sufficient to produce maximum crop production. Annual applications at 2X and 4X rates did not produce significantly higher yield than the 1X annual application rate. As all treatments, including alternating application year treatments, received manure in 2006 there was no opportunity to evaluate residual effects. As in the previous ten years, injected liquid swine manure manure resulted in significantly higher yield than broadcast and incorporated manure. Also, the nitrification inhibitor treatment grain and straw yields (Treatment 10) were not significantly different from the minus inhibitor treatment (Treatment 4), with mean yields of both treatments differing by less than 100 kg/ha (Figure 7).

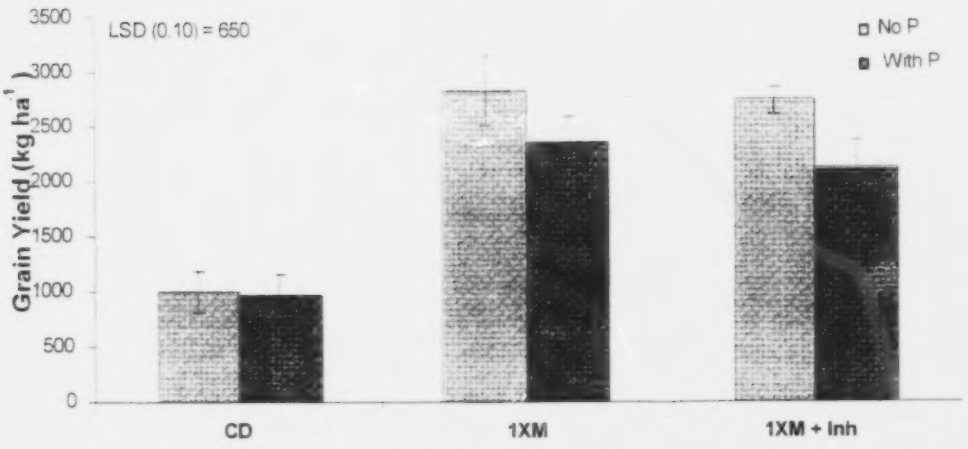


Figure 7. Grain yield comparison between the control, 1XM (37,000 L ha^{-1}) and 1XM + Inh (37,000 L ha^{-1} + nitrification inhibitor) receiving P fertilizer vs. no P fertilizer.

* Inhibitor = 0.275 ml kg^{-1} of Super N Concentrate added to swine manure before application.
** Supplemental phosphorus added at a rate of 15 kg ha^{-1} annually.

Again, as in 2005, the addition of inhibitor appears to have little agronomic benefit. Supplemental commercial P fertilizer added at this site in 2006 did not have a significant impact on flax yield in any of the treatments. In fact, there was a trend for yields to be lower in the treatments with 15 kg P_2O_5/ha added P fertilizer. Flax is a crop that, due to its tap root system and seed sensitivity to fertilizer, is difficult to effectively place P fertilizer for. Lack of response may be a consequence of placement as well as sufficient soil P being present in the manure treatments.

Additions of manure produced the expected increases in N concentration in flax grain and straw, and decreases in P concentration due to growth dilution. The addition of P fertilizer did not significantly affect the concentration of phosphorus in flax grain or straw, consistent with the lack of yield response to the added P fertilizer and indicating that adding supplemental P fertilizer had little or no effect on the P nutrition of the flax crop. Increasing rates of manure decreased the % recovery of manure nitrogen as expected. Neither the inhibitor nor the P fertilizer had a positive effect on increasing the proportion of added manure N recovered (Figure 8).

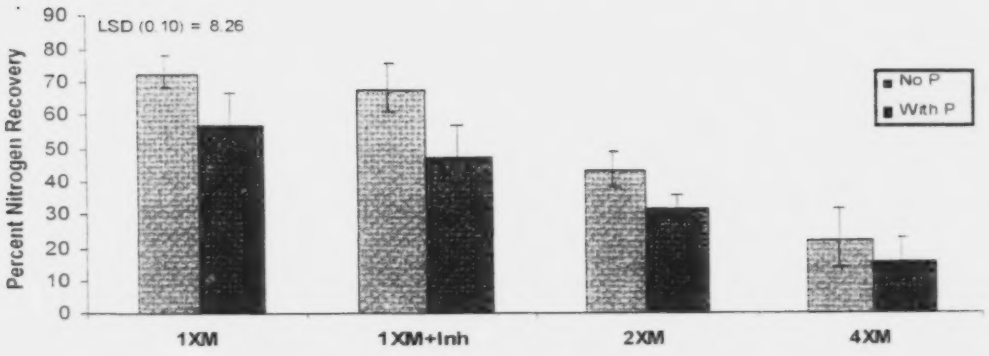


Figure 8. Nitrogen recovery for swine manure treatments calculated from grain and straw nitrogen at Dixon field site in 2006.

* Inhibitor = 0.275 ml kg^{-1} of Super N Concentrate added to swine manure before application.

** Phosphorus banded into soil at a rate of 15 kg ha^{-1} annually.

Extractable nitrate in the 0-15cm and 15-30 cm depth was significantly enhanced over the control only in the 2X and 4X treatments, as was observed in 2005. Significant accumulations of nitrate deeper in the profile (30-60 cm and 60 to 120 cm) are observed only in the 2X and 4X annual application rate treatments. The 4X annual rate of urea also produced considerable accumulation of nitrate in the 60 – 120 cm depth (~ 330 kg NO3-N/ha). It is apparent that 1X annual application rate or 2X rates every second or third year will not result in appreciable deep leaching of nitrate. As in 2005, only the 4X annual application rate extractable P level (~ 50 kg extractable P/ha 0-15cm) was significantly elevated, and all other treatments had similar extractable P levels (~ 20 -30 kg P/ha). This indicates that P loading is only an issue when high rates ie 4X annual are used, in which case there are concerns with both N and P loading. There was no evidence of P leaching in any of the treatments, as the P levels in 15-30 cm depth were all similar, around 10-15 kg P/ha. Just like in 2005, manure application increased extractable soil K in the 0-15cm depth only. Additions of swine manure and urea, especially at high repeated rates, tended to lower soil pH in the 0-15cm depth by about 0.3 to 0.5 units (from ~ 7.7 to 7.4). The soil electrical conductivity (EC) was low and similar among all treatments (~0.2 mS/cm), indicating that repeated manure applications are not causing any salinity issues at this site.

Dixon Cattle Manure Experiment 2006 (Table 2B)

The treatment effects on relative yield of flax in 2006 (Figure 9) mirror the treatment effects that were observed in 2005 for spring wheat at this site. The 4X annual application rate (applied at 4X every year since 1996) produced the highest yield of ~ 2400 kg flaxseed/ha, similar to the highest yield in the swine manure trial. It is very noteworthy that the 4X-0-0-4X treatment only yielded ~ 1700 kg /ha, indicating that the repeated application at high rate every year is needed to build-up the N supplying power

through mineralization. It appears that only the 4X applied every year for the last ten years (~60T/ha fresh manure/yr) treatment has built up the N supply sufficient for maximum yield.

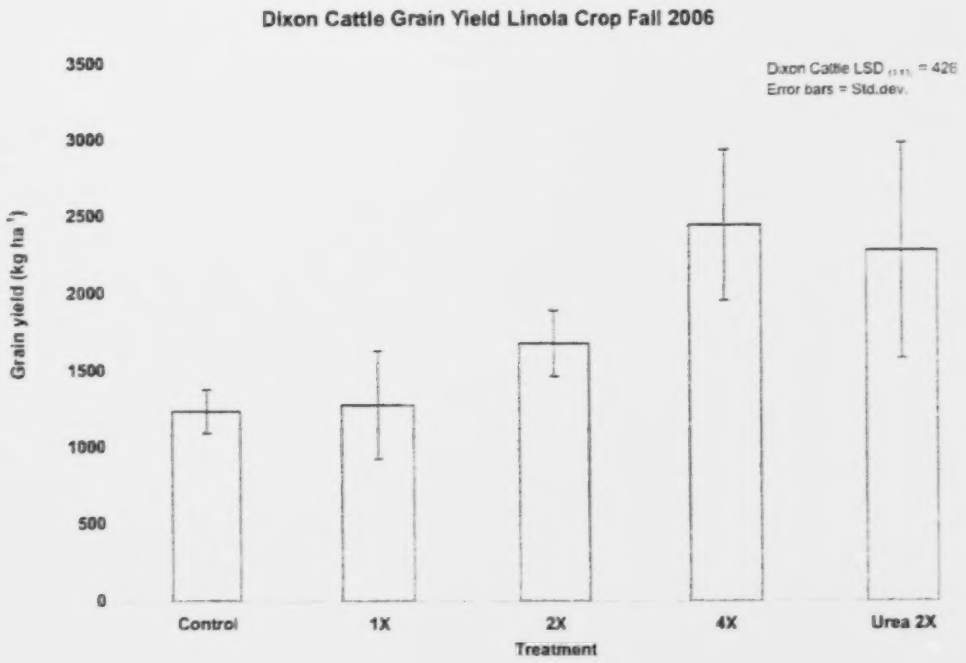


Figure 9: Flax (linola) grain yield at 2006 Dixon cattle manure trials.

Grain and straw N concentrations increased with manure or urea addition, but the greater effect of urea N on increasing short-term N availability resulted in higher concentrations with urea N than manure N at equivalent rates. Only the 4X annual application rate of cattle manure produced significantly higher flax grain N than the control. The straw N concentration was the highest in the 4X annual application rate of urea. Grain and straw P concentrations tended to decrease with manure and fertilizer applications due to yield dilution. Flax P concentrations were significantly higher in cattle manure treatments than in urea only and swine manure treatments, reflecting the large direct addition of phosphorus to the soil as cattle manure.

The only treatment with significantly elevated soil nitrate contents in the surface (0-15 cm and 15-30 cm) soil layers was the 4X annual application rate of urea. All other treatments, including the 4X annual application rate of cattle manure had similar, low levels of nitrate

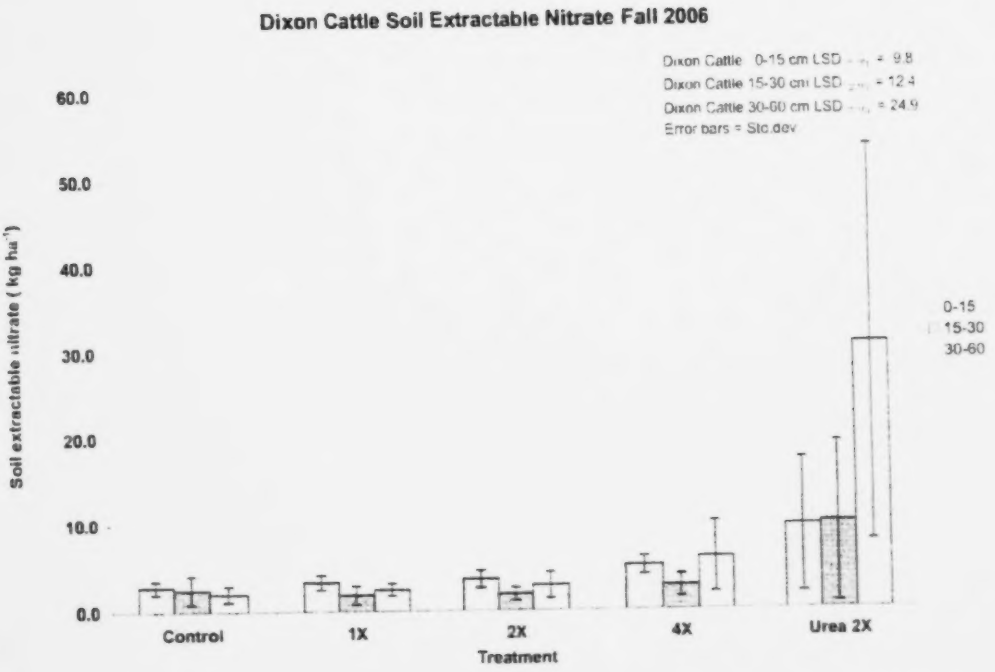


Figure 10. Soil nitrate content at three depths in manure or urea fertilizer treatments at Dixon cattle manure site sampled after harvest in fall of 2006.

Soil nitrate loading is not a major issue with cattle manure applied at the rates in this study. In the 30 to 60 cm depth increment and in the 60-120 cm depth increment, there was a trend for the 4X annual cattle manure application treatment to have elevated nitrate (~20 kg nitrate-N/ha vs. ~ 5 kg /ha in other treatments). The 4X annual urea application treatment had elevated soil nitrate content at all depths, especially below 30 cm, indicating significant downward migration of nitrate over the years in this treatment. In contrast to nitrate, there is evidence of soil P loading with the cattle manure applications. Only the 1X treatment applied every second third year shows no significant elevation of soil extractable P over the control. The 1X, 2X and 4X annual applications of cattle manure all produced significantly higher extractable P than the control or urea fertilized treatments. The 4X annual application rate of cattle manure has an excessive amount of extractable P ~ 180 kg P/ha in the 0-15cm depth, a consequence of the high P content relative to N of the cattle manure. Furthermore, there is evidence of some P migration below the 15 cm depth in the 4X annual application cattle manure treatment, with significant elevation of extractable P in the 15-30 cm depth compared to other treatments. As noted in 2005, repeated cattle manure addition also causes large increases in soil extractable potassium. Urea fertilizer applied at the 4X rate caused a significant decrease in pH of about 0.4 units compared to the unfertilized control while cattle manure had no significant impact on pH, with very little difference in mean pH among the treatments ~ 7.9. This is explained by a buffering effect of cattle manure due to its relatively high

content of bases such as calcium and carbonate, and also limited acidity due to low rates of nitrification. Compared to the unfertilized control and urea treatments, there was a trend for cattle manure application to produce a small (~0.15 mS/cm) but statistically significant increase in electrical conductivity. However, the increase is biologically unimportant, as the salt content is still well below a level that would interfere with the growth of any crop.

Melfort Swine Manure Experiment 2006 (Table 3B)

The barley crop at the Melfort site in 2006 showed a strong response to the addition of fertilizer as either swine manure or urea. Barley grain yield was more than tripled, with the highest yield of ~ 5500 kg/ha achieved at the 3X rate or 9900 gallon per acre treatment that is applied once every three years.

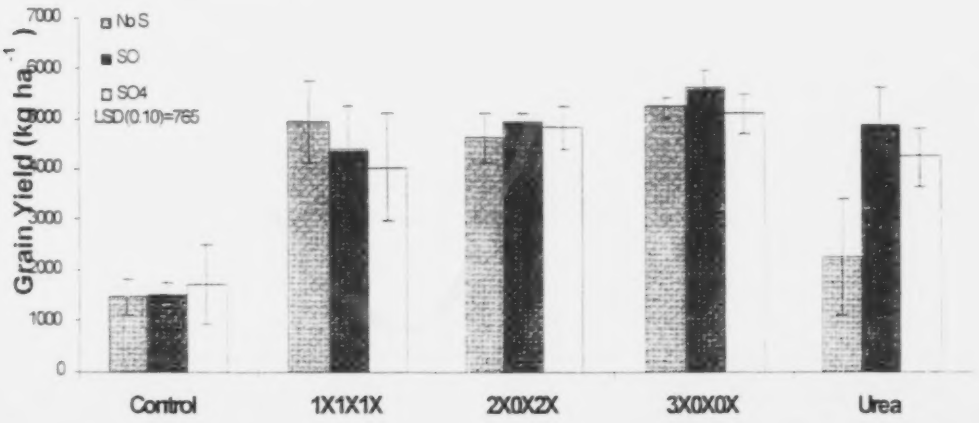


Figure 11. Barley grain yield in swine manure and urea fertilizer treatments without and with supplemental sulfur fertilizers (S^{O} elemental; SO_4 sulfate) at Melfort field site in 2006.

* Elemental sulfur banded into soil at a rate of 40 kg ha^{-1} in 2005

** Potassium sulfate banded into soil at a rate of 40 kg ha^{-1} in 2005

The 2X and 3X manure rates at this site are applied once every second and third year respectively and in the 2006 season, all treatments received manure. There was higher yield with increasing rate of manure addition at this site in 2006, likely reflecting very good moisture and growing conditions and corresponding higher nutrient demand. The supplemental sulfur fertilizer treatments applied at 40 kg S/ha in spring of 2005 did not significantly affect barley yield in 2006 except for the urea only treatments, in which case the addition of either elemental S or potassium sulfate the year before resulted in a near doubling of grain yield (from 2200 to ~4500 kg/ha) in the urea fertilized treatments. It appears that the swine manure applied in 2006 was supplying sufficient available sulfur for barley growth.

Barley grain and straw sulfur concentrations were relatively unaffected by manure addition, indicating that sufficient available sulfur was present from soil and manure to result in additional S uptake to balance the additional N supplied in the manure and not restrict barley growth and yield. The grain and straw N concentrations also did not change much with manure or fertilizer addition while plant N and S uptake increased significantly with fertilization due to increased grain and straw yield. The high yield potential would have contributed to low N concentrations (and low protein) in the barley grown at this site in 2006, even at the 3X rate of application.

As in 2005, none of the soils in the treatments showed any large accumulations of nitrate nitrogen, all the way to 120 cm depth. Without S fertilizer added, the urea fertilized treatments did show slightly but significantly higher nitrate concentrations than the manure treatments. This is a consequence of lower fertilizer nitrogen utilization in the urea treatment without supplemental S fertilizer, due to the S deficiency limiting yield and N uptake potential in this year as well as previous years. These results demonstrate the importance of balanced fertilization to reduce soil nutrient loading issues. Soil extractable P levels were not significantly influenced by manure or fertilizer addition. Overall, soil nitrogen and phosphorus loading does not appear to be an issue at the Melfort site, mainly because the 2X and 3X rates are applied only once every second or third year, rather than annually. Similarly, increases in extractable soil K are not as large at the Melfort site as at the Dixon site. It is noteworthy that extractable P and K tend to be higher in the elemental S treatments than the other treatments. This may be due to the effect of the elemental S oxidation to sulfuric acid resulting in increased solubility of P minerals and protons displacing K from the interlayer spaces of clay minerals. The soil pH and E.C. were not greatly affected by treatment, but the urea fertilizer treatments did tend to have slightly lower pH (~0.1 to 0.2 pH units lower).

Plenty Swine Manure Experiment 2006 (Table 4B)

In 2006, regimes 1 and 2 were damaged by herbicide drift and so were not harvested. Regimes 3, 4, and 5 represent alternating years of manure application with no application made for 2006 season, while regime 6 is application of manure treatment every year. Residual effects of manure application made in 2005 and in 2004 were evident in the yields of canola for 2006. As indicated previously for the soil samples taken at the end of the 2005 season, high application rates of nutrient and poor yields in the first three years of the experiment in the 1990's led to significant accumulations of residual nutrient at this site. Still, the highest canola grain and straw yields were obtained in regime 6 with annual applications of manure. Within a regime, for those regimes with higher application frequency such as regime 6, the yield tended to be higher at the low 1X manure application rate (3300 gpa) than the high 2X rate (6600 gpa). It may be concluded that production can be optimized under soil and climatic conditions similar to the Plenty site with low rates applied every year or every second year. Yields were higher under manure than with N fertilizer, predominantly due to the higher rates of nitrogen added as manure.

Grain and straw N concentrations were increased by manure addition over the control and N fertilizer treatments, reflecting greater nitrogen availability. The phosphorus concentrations of the grain and straw were not affected much by the treatments, except that the N fertilizer treatments had the lowest P concentrations due to no P fertilizer having been added since the inception of the experiment.

The soil nitrate contents in the 0-15cm depth and 15-30 cm depths were not significantly influenced by treatment. It appears that the good moisture conditions and high crop growth in 2006 contributed to removal of nitrate that had accumulated in the surface soils of the manure treatments in previous years. However, there is still a bulge of nitrate in the 30-60cm depth and 60-120 cm depths in the manured treatments that likely represents the effect of accumulation and slow migration of nitrate downward from high rates of manure N added in years past.

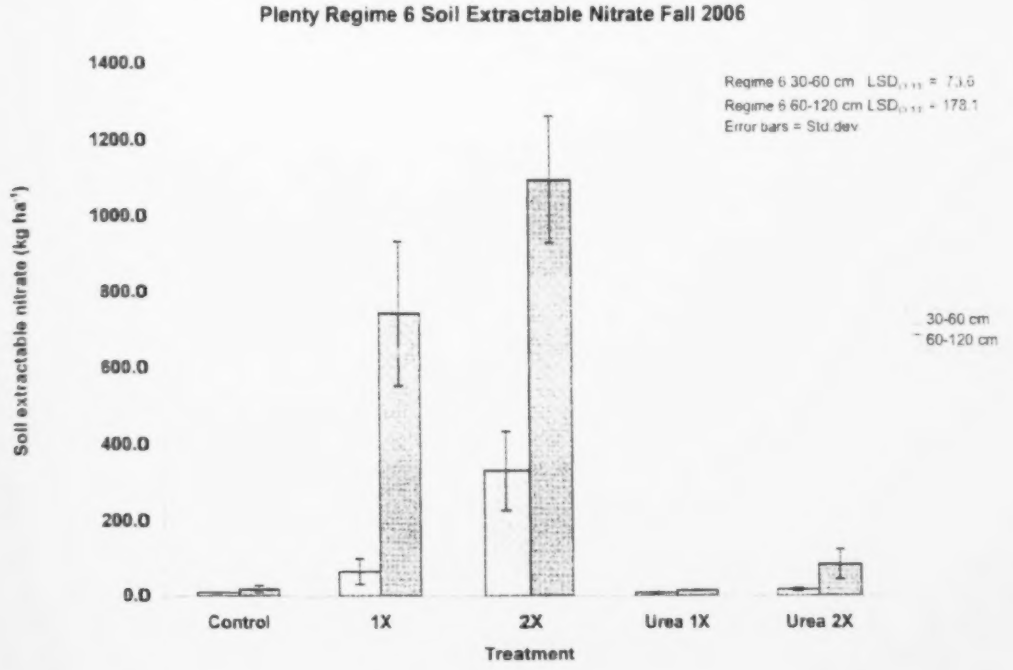


Figure 12: Sub-soil nitrate content (kg NO_3-N/ha in 30-60 cm and 60-120 cm depth) at Plenty site in fall of 2006 after harvest.

It appears that once the nitrate accumulates at depth, it is more difficult for the crop to recover and utilize this nitrogen. Therefore, one may not necessarily expect to immediately recover nitrate that has migrated to the sub-soil due to over-application of manure in previous years.

Riverhurst Swine Manure Experiment 2006 (Table 5B)

There were significant residual effects of alternating years manure applications on the oat green feed biomass grown in 2006. Even with a single application made in 1999 and no further applications (regime 1), there appeared to be a significant residual effect on yield in 2006. Applications of manure that were made the previous year, or even two years previously resulted in yields that were similar to the annual application regime (regime 6). As at the Plenty site, there was little difference in yield between low and high rate of manure application, even in regimes with reduced frequency of application. The low rate of manure applied now every year or every second year would appear to be sufficient, given the apparent residual effects of large applications of nutrient as manure at both Plenty and Riverhurst sites in the first years of the study, even at the low rates. High yields in the check are explained by residual effect of fertilizer applications made across all treatments in 2004 when potatoes were grown. Similar to the Plenty site, yields under manure were higher than with N fertilizer due to more N added as manure over the years.

The N concentration (and protein) in the oat green feed harvested for fodder was very responsive to manure treatment, even in regimes with reduced application frequency. The N concentration (mg/g) was increased from about 6-7 in the check treatments to about 10-12 in the high (2X) treatments. The N concentrations were similar in the high manure rate treatments among regimes, indicating N sufficiency with reduced frequency as well as annual application.

There was no evidence of large accumulations of soil nitrate in the surface or sub-surface horizons at the Riverhurst site, consistent with observations made in 2005. This site differs from the Plenty site in that it is irrigated with high crop nutrient removal potential, especially when greenfeed is grown, and also potential for greater losses of soil nitrate through leaching or denitrification. Unfortunately, due to a layer of boulders and rock below about 90cm, it is not possible to deep sample this site. Soil extractable P levels are increased over the control in the manure treatments, but levels are still less than 50 kg P/ha in the surface soil (Figure 13).

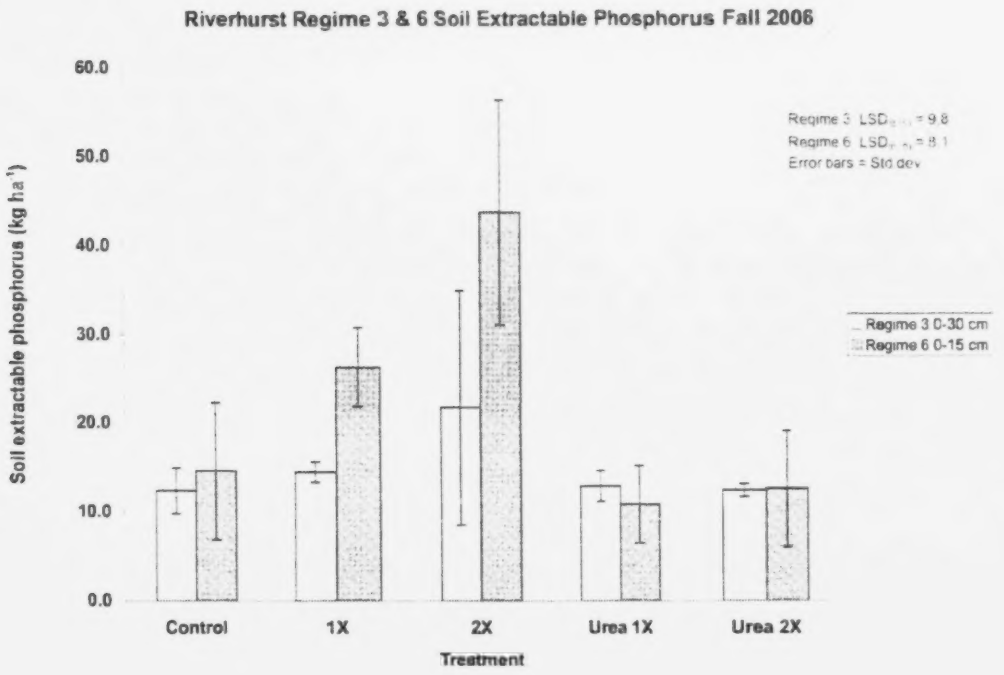


Figure 13. Soil extractable (modified Kelowna) extractable P for 0-15cm depth of Regime 6 and 0-30cm depth of Regime 3 sampled in fall of 2006 after harvest at Riverhurst site.

There is no evidence of leaching of P to the 15-30cm depth. Again, high crop removal of nutrient may be mitigating build-up of soil P or K at this site. Soil pH tended to be slightly lower in the high rate manure treatment.

2006 Field Season Yield, Crop and Soil Nutrients
TABLES 1B to 5B

TABLE 1B Dixon Swine Manure Site 2006 Yield, Crop and Soil Nutrients

2006 Linola (Flax) Crop Harvest — Hog Manure Amended Plots

Rate of Manure Application-One Time

Trt	97	98	99	0	1	2	3	4	5	6	N	Grain Yld		Straw Yld		Grain N		Straw N		Grain P		Straw P		pH		E.C.		NO_3		NH_4		P		K	
	####	1998	1999	2000	2001	2002	2003	2004	2005	2006																									
2	0	0	0	0	0	0	0	0	0	0	4	996	192	1002	223	21.4	1.2	3.7	0.5	5.2	0.3	1.0	0.4	7.7	0.1	0.21	0.08	5.1	0.5	4.6	1.0	21.0	5.8	627.3	151.2
3	1	0	0	1	0	0	1	0	0	1	4	2243	537	2507	1068	23.2	0.8	4.3	0.4	4.0	0.3	0.5	0.3	7.7	0.1	0.24	0.07	5.6	0.9	4.0	0.8	17.9	4.1	778.1	286.9
5	2	0	0	2	0	0	2	0	0	2	4	2965	136	3457	330	25.5	0.5	4.0	0.4	3.4	0.4	0.2	0.1	7.9	0.3	0.23	0.05	6.9	1.1	6.3	1.5	18.0	5.9	863.9	155.7
8	4	0	0	4	0	0	4	0	0	4	4	2502	368	2661	601	28.0	0.3	5.2	0.8	3.7	0.3	0.3	0.1	7.6	0.3	0.22	0.08	11.3	6.8	7.4	5.1	24.4	11.3	992.8	239.5

Rate of Manure Application-Annual

Trt	97	98	99	0	1	2	3	4	5	6	N	Grain Yld		Straw Yld		Grain N		Straw N		Grain P		Straw P		pH		E.C.		NO_3		NH_4		P		K	
	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006																									
2	0	0	0	0	0	0	0	0	0	0	4	996	192	1002	223	21.4	1.2	3.7	0.5	5.2	0.3	1.0	0.4	7.7	0.1	0.21	0.08	5.1	0.5	4.6	1.0	21.0	5.8	627.3	151.2
4	1	1	1	1	1	1	1	1	1	1	4	2839	319	3353	739	26.6	0.9	4.9	1.1	3.7	0.3	0.4	0.2	7.8	0.2	0.23	0.08	6.4	1.1	4.4	0.8	22.8	10.7	874.5	284.1
7	2	2	2	2	2	2	2	2	2	2	4	3080	285	3513	292	28.2	2.6	5.1	0.5	3.6	0.2	0.2	0.1	7.8	0.1	0.27	0.12	15.8	11.3	5.9	1.7	24.2	6.9	1259.6	341.9
9	4	4	4	4	4	4	4	4	4	4	4	2963	347	3450	884	28.6	2.5	6.9	1.9	3.5	0.6	0.2	0.1	7.6	0.4	0.32	0.17	17.9	15.1	5.0	1.0	48.0	20.1	1404.3	271.6

Rate of Manure Application-Annual & Skipped

Trt	97	98	99	0	1	2	3	4	5	6	N	Grain Yld		Straw Yld		Grain N		Straw N		Grain P		Straw P		pH		E.C.		NO_3		NH_4		P		K	
	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006																									
2	0	0	0	0	0	0	0	0	0	0	4	996	192	1002	223	21.4	1.2	3.7	0.5	5.2	0.3	1.0	0.4	7.7	0.1	0.21	0.08	5.1	0.5	4.6	1.0	21.0	5.8	627.3	151.2
3	1	0	0	1	0	0	1	0	0	1	4	2243	537	2507	1068	23.2	0.8	4.3	0.4	4.0	0.3	0.5	0.3	7.7	0.1	0.24	0.07	5.6	0.9	4.0	0.8	17.9	4.1	778.1	286.9
4	1	1	1	1	1	1	1	1	1	1	4	2839	319	3353	739	26.6	0.9	4.9	1.1	3.7	0.3	0.4	0.2	7.8	0.2	0.23	0.08	6.4	1.1	4.4	0.8	22.8	10.7	874.5	284.1
5	2	0	0	2	0	0	2	0	0	2	4	2965	136	3457	330	25.5	0.5	4.0	0.4	3.4	0.4	0.2	0.1	7.9	0.3	0.23	0.05	6.9	1.1	6.3	1.5	18.0	5.9	863.9	155.7
7	2	2	2	2	2	2	2	2	2	2	4	3080	285	3513	292	28.2	2.6	5.1	0.5	3.6	0.2	0.2	0.1	7.8	0.1	0.27	0.12	15.8	11.3	5.9	1.7	24.2	6.9	1259.6	341.9
8	4	0	0	4	0	0	4	0	0	4	4	2502	368	2661	601	28.0	0.3	5.2	0.8	3.7	0.3	0.3	0.1	7.6	0.3	0.22	0.08	11.3	6.8	7.4	5.1	24.4	11.3	992.8	239.3
9	4	4	4	4	4	4	4	4	4	4	4	2963	347	3450	884	28.6	2.5	6.9	1.9	3.5	0.6	0.2	0.1	7.6	0.4	0.32	0.17	17.9	15.1	5.0	1.0	48.0	20.1	1404.3	271.6
LSD												384		696		1.4		1.0		0.4		0.2		0.3		0.51		9.4		2.3		8.3		224.5	

Method of Manure Application-Annual

Trt	Method	N	Grain Yld.		Straw Yld.		Grain N		Straw N		Grain P		Straw P		pH		E.C.		NO_3		NH_4		P		K	
1	Control-Average	4	1049	227	1131	315	21.6	2.1	3.3	0.6	5.1	0.2	0.8	0.3	7.9	0.3	0.20	0.02	5.5	0.9	5.2	2.1	22.3	7.8	686.2	174.7
2	Control-Disturbed	4	996	192	1002	223	21.4	1.2	3.7	0.5	5.2	0.3	1.0	0.4	7.7	0.1	0.21	0.08	5.1	0.5	4.6	1.0	21.0	5.8	627.3	151.2
4	1X1X1X1X1X1X1X Injection @12"	4	2839	319	3353	739	26.6	0.9	4.9	1.1	3.7	0.3	0.4	0.2	7.8	0.2	0.23	0.08	6.4	1.1	4.4	0.8	22.8	10.7	874.5	284.1
10	1X1X1X1X1X1X1X Injection @12" + INHIBITOR (05.06 added w/manure)	4	2737	132	3401	489	27.3	2.2	3.9	0.4	3.6	0.5	0.2	0.1	8.0	0.1	0.22	0.03	6.0	0.8	4.0	1.3	23.2	13.9	822.0	281.1
11	1X1X1X1X1X1X1X +H2O	4	1096	205	1187	287	21.8	1.5	3.4	0.3	5.0	0.4	0.8	0.5	7.8	0.2	1.08	1.66	5.4	0.4	5.7	0.6	19.9	6.4	771.8	187.3
12	1X1X1X 1X1X1X1XBroadcast & Incorporated	4	2358	371	2417	855	25.1	1.6	4.4	0.7	4.0	0.5	0.5	0.2	7.8	0.2	0.20	0.02	5.5	0.5	6.3	2.5	18.2	5.1	963.3	356.1

Source and Rate of Annual N Application-Balanced

Trt		97	98	99	0	1	2	3	4	5	6	N	Grain Yld		Straw Yld		Grain N		Straw N		Grain P		Straw P		pH		E.C.		NO_3		NH_4		P		K	
		1997	1998	1999	2000	2001	2002	2003	2004	2005	2006																									
2	Hog	0	0	0	0	0	0	0	0	0	0	4	996	192	1002	223	21.4	1.2	3.7	0.5	5.2	0.3	1.0	0.4	7.7	0.1	0.21	0.08	5.1	0.5	4.6	1.0	21.0	5.8	627.3	151.2
4	Hog	1	1	1	1	1	1	1	1	1	1	4	2839	319	3353	739	26.6	0.9	4.9	1.1	3.7	0.3	0.4	0.2	7.8	0.2	0.23	0.08	6.4	1.1	4.4	0.8	22.8	10.7	874.5	284.1
7	Hog	2	2	2	2	2	2	2	2	2	2	4	3080	285	3513	292	28.2	2.6	5.1	0.5	3.6	0.2	0.2	0.1	7.8	0.1	0.27	0.12	15.8	11.3	5.9	1.7	24.2	6.9	1259.6	341.9
9	Hog	4	4	4	4	4	4	4	4	4	4	4	2963	347	3450	884	28.6	2.5	6.9	1.9	3.5	0.6	0.2	0.1	7.6	0.4	0.32	0.17	17.9	15.1	5.0	1.0	48.0	20.1	1404.3	271.6
1	Hog	0	0	0	0	0	0	0	0	0	0	4	1049	227	1131	315	21.6	2.1	3.3	0.6	5.1	0.2	0.8	0.3	7.9	0.3	0.20	0.02	5.5	0.9	5.2	2.1	22.3	7.8	686.2	174.7
13	Urea	1	1	1	1	1	1	1	1	1	1	4	2312	640	2885	555	25.4	1.0	4.2	0.9	2.9	0.7	0.2	0.1	7.7	0.4	0.19	0.05	6.9	3.5	5.2	1.6	12.5	1.8	529.1	107.6
14	Urea	2	2	2	2	2	2	2	2	2	2	4	2463	603	2723	353	25.8	1.5	4.3	0.5	3.0	0.5	0.2	0.1	7.5	0.3	0.27	0.18	8.7	2.3	6.2	0.4	14.7	3.2	657.3	212.8
15	Urea	4	4	4	4	4	4	4	4	4	4	4	2668	332	3108	610	26.3	1.6	5.7	1.0	2.8	0.2	0.1	0.0												

Alternating Hog Manure Application

Trt	97	98	99	0	1	2	3	4	5	6	N	Grain Yld		Straw Yld		Grain N		Straw N		Grain P		Straw P		pH		E.C.		NO_3		NH_4		P		K	
	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006																									
1	0	0	0	0	0	0	0	0	0	0	4	1049	227	1131	315	21.6	2.1	3.3	0.6	5.1	0.2	0.8	0.3	7.9	0.3	0.20	0.02	5.5	0.9	5.2	2.1	22.3	7.8	686.2	174.7
2	0	0	0	0	0	0	0	0	0	0	4	996	192	1002	223	21.4	1.2	3.7	0.5	5.2	0.3	1.0	0.4	7.7	0.1	0.21	0.08	5.1	0.5	4.6	1.0	21.0	5.8	627.3	151.2
5	2	0	0	2	0	0	2	0	0	2	4	2965	136	3457	330	25.5	0.5	4.0	0.4	3.4	0.4	0.2	0.1	7.9	0.3	0.23	0.05	6.9	1.1	6.3	1.5	18.0	5.9	863.9	155.7
6	2	0	2	2	0	2	0	2	0	2	4	2877	319	3598	533	26.1	1.3	4.8	0.9	3.4	0.3	0.2	0.2	7.9	0.4	0.30	0.15	18.0	20.4	6.3	1.1	17.8	0.7	848.3	307.6
7	2	2	2	2	2	2	2	2	2	2	4	3080	285	3513	292	28.2	2.6	5.1	0.5	3.6	0.2	0.2	0.1	7.8	0.1	0.27	0.12	15.8	11.3	5.9	1.7	24.2	6.9	1259.6	341.9
LSD												384		696		1.4		1.3		0.4		0.2		0.3		0.51		9.4		2.3		8.3		224.5	

Note 1. Crop harvest (grain and straw weights) means in kg ha^{-1}
2. Grain and Straw Total N and Total P means in mg g^{-1}
3. Soil Extractable (NH_4, NO_3) P & K means in kg ha^{-1}
4. Electrical conductivity means in mS cm^{-1}
5. Soil analysis conducted on Fall 2006 samples
6. Means in the first column are followed by standard deviations in the second column
7. N=Number of observations
8. LSD (0.10) calculated at p ≤ 0.10

Soil Analysis (15-30 cm)										Soil Analysis (30-60 cm)			
pH		E.C.		NO_3		NH_4		P	K	NO_3		NH_4	
7.6	0.2	0.53	0.92	3.9	0.5	5.8	0.8	12.6	5.1	307.7	89.4	7.6	0.9	25.1	19.4
7.8	0.1	0.20	0.07	4.4	0.3	5.5	1.4	11.1	3.4	328.5	103.8	7.8	0.5	15.8	10.4
7.9	0.3	0.41	0.20	7.7	4.6	6.5	1.0	8.4	0.9	285.8	30.4	15.7	5.9	13.0	3.3
7.9	0.3	0.24	0.07	16.7	16.9	5.3	1.1	8.3	1.8	269.9	102.8	56.6	15.7	7.6	2.7
7.6	0.2	0.53	0.92	3.9	0.5	5.8	0.8	12.6	5.1	307.7	89.4	7.6	0.9	25.1	19.4
7.8	0.3	0.21	0.05	5.6	2.9	5.3	1.8	13.1	6.7	260.7	104.3	22.3	13.6	14.0	1.1
7.9	0.3	0.22	0.10	17.0	23.4	5.6	0.4	11.1	1.3	348.5	93.7	102.0	76.6	19.9	12.1
7.9	0.2	0.47	0.43	59.1	89.4	4.3	0.9	12.4	5.5	329.7	69.2	366.0	247.5	26.4	33.1
7.6	0.2	0.53	0.92	3.9	0.5	5.8	0.8	12.6	5.1	307.7	89.4	7.6	0.9	25.1	19.4
7.8	0.1	0.20	0.07	4.4	0.3	5.5	1.4	11.1	3.4	328.5	103.8	7.8	0.5	15.8	10.4
7.8	0.3	0.21	0.05	5.6	2.9	5.3	1.8	13.1	6.7	260.7	104.3	22.3	13.6	14.0	1.1
7.9	0.3	0.41	0.20	7.7	4.6	6.5	1.0	8.4	0.9	285.8	30.4	15.7	5.9	13.0	3.3
7.9	0.3	0.22	0.10	17.0	23.4	5.6	0.4	11.1	1.3	348.5	93.7	102.0	76.6	19.9	12.1
7.9	0.3	0.24	0.07	16.7	16.9	5.3	1.1	8.3	1.8	269.9	102.8	56.6	15.7	7.6	2.7
7.9	0.2	0.47	0.43	59.1	89.4	4.3	0.9	12.4	5.5	329.7	69.2	366.0	247.5	26.4	33.1
0.2		0.48		31.5		1.5		6.4		84.7		59.6		15.1	

Soil Analysis (15-30 cm)										Soil Analysis (30-60 cm)			
pH		E.C.		NO_3		NH_4		P	K	NO_3		NH_4	
7.6	0.2	0.19	0.11	4.4	0.3	4.9	2.6	12.0	3.5	268.1	55.2	7.8	0.8	11.4	3.7
7.6	0.2	0.63	0.92	3.9	0.5	5.8	0.8	13.6	5.1	307.7	89.4	7.6	0.9	25.1	19.4
7.8	0.3	0.21	0.05	5.6	2.9	5.3	1.8	13.1	6.7	260.7	104.3	22.3	13.6	14.0	1.1
7.9	0.1	0.64	0.55	4.7	0.4	5.2	1.2	11.2	4.4	274.3	81.2	13.0	2.7	20.4	23.9
7.8	0.1	0.65	0.62	4.3	0.4	6.4	1.1	10.6	1.6	316.7	80.3	8.2	0.7	13.0	5.6
7.9	0.2	0.19	0.01	3.9	0.3	6.3	1.6	9.6	1.1	296.4	91.3	8.5	0.7	15.7	6.2
7.6	0.2	0.53	0.92	3.9	0.5	5.8	0.8	12.6	5.1	307.7	89.4	7.6	0.9	25.1	19.4
7.8	0.3	0.21	0.05	5.6	2.9	5.3	1.8	13.1	6.7	260.7	104.3	22.3	13.6	14.0	1.1
7.9	0.3	0.22	0.10	17.0	23.4	5.6	0.4	11.1	1.3	348.5	93.7	102.0	76.6	19.9	12.1
7.9	0.2	0.47	0.43	59.1	89.4	4.3	0.9	12.4	5.5	329.7	69.2	366.0	247.5	26.4	33.1
7.8	0.2	0.19	0.11	4.4	0.3	4.9	2.6	12.0	3.5	268.1	55.2	7.8	0.8	11.4	3.7
7.8	0.2	0.87	1.06	17.2	9.5	5.9	1.8	12.1	2.9	231.5	20.5	23.6	15.6	10.2	5.7
7.9	0.4	0.29	0.26	21.2	32.6	6.1	0.7	16.0	12.6	251.7	78.1	43.9	19.6	15.1	10.8
7.7	0.1	0.35	0.38	16.0	11.4	5.8	1.5	9.1	1.6	282.4	35.9	288.0	124.1	14.0	8.0
7.6	0.2	0.19	0.11	4.4	0.3	4.9	2.6	12.0	3.5	268.1	55.2	7.8	0.8	11.4	3.7
7.6	0.2	0.63	0.92	3.9	0.5	5.8	0.8	13.6	5.1	307.7	89.4	7.6	0.9	25.1	19.4
7.9	0.3	0.41	0.20	7.7	4.6	6.5	1.0	8.4	0.9	285.8	30.4	15.7	5.9	13.0	3.3
7.8	0.2	0.75	0.49	43.0	30.4	6.1	0.7	13.6	10.3	261.9	122.7	29.6	14.4	9.4	1.4
7.9	0.3	0.22	0.10	17.0	23.4	5.6	0.4	11.1	1.3	348.5	93.7	102.0	76.6	19.9	12.1
0.2		0.48		31.5		1.5		6.4		84.7		59.6		15.1	

TABLE 1B (continued) Dixon Swine Site 2006 Yield, Crop, Soil Nutrients

2006 Linola (Flax) Crop Harvest — **Hog Manure + Phosphorus Amended Plots**

Rate of Manure Application One Time

Trt	97 1997	98 1998	99 1999	0 2000	1 2001	2 2002	3 2003	4 2004	5 2005	6 2006
2	0	0	0	0	0	0	0	0	0	0
3	1	0	0	1	0	0	1	0	0	1
5	2	0	0	2	0	0	2	0	0	2
8	4	0	0	4	0	0	4	0	0	4

Rate of Manure Application Annual

Trt	97 1997	98 1998	99 1999	0 2000	1 2001	2 2002	3 2003	4 2004	5 2005	6 2006
2	0	0	0	0	0	0	0	0	0	0
4	1	1	1	1	1	1	1	1	1	1
7	2	2	2	2	2	2	2	2	2	2
9	4	4	4	4	4	4	4	4	4	4

Rate of Manure Application Annual & Skipped

Trt	97 1997	98 1998	99 1999	0 2000	1 2001	2 2002	3 2003	4 2004	5 2005	6 2006
2	0	0	0	0	0	0	0	0	0	0
3	1	0	0	1	0	0	1	0	0	1
4	1	1	1	1	1	1	1	1	1	1
5	2	0	0	2	0	0	2	0	0	2
7	2	2	2	2	2	2	2	2	2	2
8	4	0	0	4	0	0	4	0	0	4
9	4	4	4	4	4	4	4	4	4	4

Trt	N	Crop Harvest Fall 2006 Grain Yld		Straw Yld		Crop Sample N & P Analysis milligram nutrient / g Grain N		Straw N		Grain P		Straw P		Soil Analysis (0-15 cm) pH		E.C.		NO_3		NH_4		P		K	
2	4	970	187	833	209	23.2	1.4	3.6	0.7	4.9	0.2	0.7	0.3	7.8	0.5	0.25	0.09	4.5	1.5	7.6	2.6	25.2	3.6	532.3	148.6
3	4	2262	292	2051	308	25.8	1.3	4.0	0.9	3.8	0.2	0.4	0.1	7.7	0.4	0.22	0.01	4.9	1.3	5.6	1.4	24.2	4.5	602.4	182.5
5	4	2768	251	2882	333	27.5	2.3	4.2	0.8	3.5	0.3	0.3	0.1	7.6	0.3	0.25	0.09	6.3	0.9	7.2	1.1	25.4	12.2	598.8	272.8
8	4	2199	378	2453	691	28.6	1.7	4.7	0.2	3.5	0.3	0.2	0.1	7.4	0.6	0.19	0.06	7.3	3.1	6.4	2.3	31.4	15.1	909.0	240.5
2	4	970	187	833	209	23.2	1.4	3.5	0.7	4.9	0.2	0.7	0.3	7.8	0.5	0.25	0.09	4.5	1.5	7.6	2.6	25.2	3.6	532.3	148.6
4	4	2364	234	2606	585	28.4	2.2	4.5	1.3	3.5	0.2	0.3	0.2	7.4	0.8	0.22	0.06	12.6	11.5	7.4	2.4	26.5	6.0	719.6	129.5
7	4	2504	356	2912	768	27.5	1.5	5.3	1.0	3.3	0.4	0.2	0.1	7.6	0.5	0.21	0.04	7.7	3.3	7.0	1.5	31.0	8.9	978.1	202.3
9	4	2384	239	2424	505	29.1	1.8	6.1	0.5	3.1	0.2	0.2	0.0	7.3	0.5	0.24	0.08	7.4	2.4	7.9	1.2	54.0	10.3	1322.7	120.2
2	4	970	187	833	209	23.2	1.4	3.6	0.7	4.9	0.2	0.7	0.3	7.8	0.5	0.25	0.09	4.5	1.5	7.6	2.6	25.2	3.6	532.3	148.6
3	4	2262	292	2051	308	25.8	1.3	4.0	0.9	3.8	0.2	0.4	0.1	7.7	0.4	0.22	0.01	4.9	1.3	5.6	1.4	24.2	4.5	602.4	182.5
4	4	2364	234	2606	585	28.4	2.2	4.5	1.3	3.5	0.2	0.3	0.2	7.4	0.8	0.22	0.06	12.6	11.5	7.4	2.4	26.5	6.0	719.6	129.5
5	4	2768	251	2882	333	27.5	2.3	4.2	0.8	3.5	0.3	0.3	0.1	7.6	0.3	0.25	0.09	6.3	0.9	7.2	1.1	25.4	12.2	598.8	272.8
7	4	2504	356	2912	768	27.5	1.5	5.3	1.0	3.3	0.4	0.2	0.1	7.6	0.5	0.21	0.04	7.7	3.3	7.0	1.5	31.0	8.9	978.1	202.3
8	4	2199	378	2453	691	28.6	1.7	4.7	0.2	3.5	0.3	0.2	0.1	7.4	0.6	0.19	0.06	7.3	3.1	6.4	2.3	31.4	15.1	909.0	240.5
9	4	2384	239	2424	505	29.1	1.8	6.1	0.8	3.1	0.2	0.2	0.0	7.3	0.5	0.24	0.08	7.4	2.4	7.9	1.2	54.0	10.3	1322.7	120.2
LSD		347		598		1.8		1.0		0.3		0.1		0.4		0.08		10.1		2.1		11.8		192.2	

Method of Manure Application Annual

Trt	Method
1	Control-Average
2	Control-Disturbed
4	1X1X1X1X1X1X1X Injection @12
10	1X1X1X1X1X1X1X Injection @12 + dunBRTOR I2005&06 added w/manure
11	1X1X1X1X1X1X1X +H2O
12	1X1X1X 1X1X1X1XBroadcast & Incorporated

Trt	N	Crop Harvest Fall 2006 Grain Yld		Straw Yld		Crop Sample N & P Analysis Grain N		Straw N		Grain P		Straw P		Soil Analysis (0-15 cm) pH		E.C.		NO_3		NH_4		P		K	
1	4	844	184	716	194	22.8	0.9	3.8	0.5	5.1	0.2	0.8	0.2	7.8	0.4	0.23	0.10	3.2	1.2	5.5	1.1	29.6	17.9	465.9	150.1
2	4	970	187	833	209	23.2	1.4	3.6	0.7	4.9	0.2	0.7	0.3	7.8	0.5	0.25	0.09	4.5	1.5	7.6	2.6	25.2	3.6	532.3	148.6
4	4	2364	234	2606	585	28.4	2.2	4.5	1.3	3.5	0.2	0.3	0.2	7.4	0.8	0.22	0.06	12.6	11.5	7.4	2.4	26.5	6.0	719.6	129.5
10	4	2115	257	2468	364	28.5	2.9	3.9	0.7	3.5	0.4	0.2	0.1	7.9	0.4	0.22	0.04	5.7	1.0	7.8	1.9	22.1	4.8	652.0	89.8
11	4	1188	286	1435	349	22.9	0.7	3.7	0.5	5.0	0.2	0.8	0.2	7.8	0.3	0.20	0.03	3.6	0.4	6.0	2.3	20.7	7.6	570.8	105.6
12	4	2059	261	2220	456	26.2	1.9	3.8	1.2	4.0	0.4	0.3	0.1	7.6	0.5	0.20	0.05	4.4	0.9	7.5	1.1	18.8	3.8	678.2	161.9

Source and Rate of Annual N Application Balanced

Trt		97 1997	98 1998	99 1999	0 2000	1 2001	2 2002	3 2003	4 2004	5 2005	6 2006
2	Hog	0	0	0	0	0	0	0	0	0	0
4	Hog	1	1	1	1	1	1	1	1	1	1
7	Hog	2	2	2	2	2	2	2	2	2	2
9	Hog	4	4	4	4	4	4	4	4	4	4
1	Hog	0	0	0	0	0	0	0	0	0	0
13	Urea	1	1	1	1	1	1	1	1	1	1
14	Urea	2	2	2	2	2	2	2	2	2	2
15	Urea	4	4	4	4	4	4	4	4	4	4

Trt	N	Crop Harvest Fall 2006 Grain Yld		Straw Yld		Crop Sample N & P Analysis Grain N		Straw N		Grain P		Straw P		Soil Analysis (0-15 cm) pH		E.C.		NO_3		NH_4		P		K	
2	4	970	187	833	209	23.2	1.4	3.6	0.7	4.9	0.2	0.7	0.3	7.8	0.5	0.25	0.09	4.5	1.5	7.6	2.6	25.2	3.6	532.3	148.6
4	4	2364	234	2606	585	28.4	2.2	4.5	1.3	3.5	0.2	0.3	0.2	7.4	0.8	0.22	0.06	12.6	11.5	7.4	2.4	26.5	6.0	719.6	129.5
7	4	2504	356	2912	768	27.5	1.5	5.3	1.0	3.3	0.4	0.2	0.1	7.6	0.5	0.21	0.04	7.7	3.3	7.0	1.5	31.0	8.9	978.1	202.3
9	4	2384	239	2424	505	29.1	1.8	6.1	0.8	3.1	0.2	0.2	0.0	7.3	0.5	0.24	0.08	7.4	2.4	7.9	1.2	54.0	10.3	1322.7	120.2
1	4	844	184	716	194	22.8	0.9	3.8	0.5	5.1	0.2	0.8	0.2	7.8	0.4	0.23	0.10	3.2	1.2	5.5	1.1	29.6	17.9	465.9	150.1
13	4	2125	84	2326	204	27.3	2.3	3.5	0.7	3.2	0.4	0.2	0.1	7.9	0.3	0.24	0.09	4.5	0.4	8.0	0.6	16.2	2.7	579.3	126.1
14	4	2173	212	2295	507	29.1	2.8	3.6	0.4	3.1	0.3	0.1	0.1	7.6	0.7	0.24	0.11	4.0	1.0	8.6	1.4	16.1	2.5	477.6	115.5
15	4	2045	393	2350	796	28.1	1.7	5.4	1.3	3.0	0.3	0.2	0.1	7.1	1.1	0.22	0.07	22.7	30.5	10.9	4.8	21.2	0.6	434.5	61.7

Alternating Hog Manure Application

Trt	97 1997	98 1998	99 1999	0 2000	1 2001	2 2002	3 2003	4 2004	5 2005	6 2006
1	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0
5	2	0	0	2	0	0	2	0	0	2
6	2	0	2	2	0	2	2	0	2	2
7	2	2	2	2	2	2	2	2	2	2

Trt	N	Crop Harvest Fall 2006 Grain Yld		Straw Yld		Crop Sample N & P Analysis Grain N		Straw N		Grain P		Straw P		Soil Analysis (0-15 cm) pH		E.C.		NO_3		NH_4		P		K	
1	4	844	184	716	194	22.8	0.9	3.8	0.5	5.1	0.2	0.8	0.2	7.8	0.4	0.23	0.10	3.2	1.2	5.5	1.1	29.6	17.9	465.9	150.1
2	4	970	187	833	209	23.2	1.4	3.6	0.7	4.9	0.2	0.7	0.3	7.8	0.5	0.25	0.09	4.5	1.5	7.6	2.6	25.2	3.6	532.3	148.6
5	4	2768	251	2882	333	27.5	2.3	4.2	0.8	3.5	0.3	0.3	0.1	7.8	0.3	0.25	0.09	6.3	0.9	7.2	1.1	25.4	12.2	598.8	272.8
6	4	2347	539	2436	903	27.2	2.6	4.6	1.2	3.3	0.2	0.2	0.1	7.8	0.4	0.20	0.03	6.5	3.2	7.3	2.0	28.9	24.4	664.0	343.6
7	4	2504	356	2912	768	27.5	1.5	5.3	1.0	3.3	0.4	0.2	0.1	7.6	0.5	0.21	0.04	7.7	3.3	7.0	1.5	31.0	8.9	978.1	202.3
LSD		347		598		1.8		1.0		0.3		0.1		0.4		0.08		10.1		2.1		11.8		192.2	

Note 1. Crop harvest (grain and straw yields) means in kg ha^{-1}
2. Grain and Straw Total N and Total P means in mg g^{-1}
3. Soil Extractable NH_4, NO_3 P & K means in kg ha^{-1}
4. Electrical conductivity means in mS cm^{-1}
5. Soil analysis conducted on Fall 2006 samples
6. Phosphorus was added in Fall 2005 at a rate of 30kg/ha of 11-51-0
7. Means in the first column are followed by standard deviations in the second column
8. N=Number of observations
9. LSD (0.10) calculated at p ≤ 0.10

Soil Analysis (15-30 cm)										Soil Analysis (30-60 cm)				Soil Analysis (60-120 cm)			
pH		E.C.		NO_3		NH_4		P		K		NO_3		NH_4		NO_3		NH_4	
7.6	0.7	0.35	0.27	2.7	1.2	7.3	1.7	16.2	8.2	183.4	25.0	4.2	2.1	15.3	3.6	8.8	4.6	50.4	27.8
7.9	0.3	0.23	0.10	2.6	1.7	7.4	3.1	12.2	7.7	260.6	83.8	5.5	2.1	21.8	17.8	14.6	6.3	13.5	10.3
7.7	0.3	0.76	1.25	9.5	12.4	14.5	14.4	14.7	3.6	379.7	279.2	22.4	8.7	26.7	11.6	25.8	9.1	21.9	14.6
7.7	0.6	0.20	0.07	8.9	10.2	5.9	1.5	13.6	4.6	224.7	65.2	79.8	30.5	20.0	11.4	35.1	12.9	18.7	14.4
7.6	0.7	0.35	0.27	2.7	1.2	7.3	1.7	16.2	8.2	183.4	25.0	4.2	2.1	15.3	3.6	8.8	4.6	50.4	27.8
7.3	0.9	0.76	0.71	12.6	12.9	5.9	1.9	17.8	11.2	210.3	55.3	20.8	17.4	12.2	3.2	29.0	10.7	29.8	15.5
7.7	0.9	0.19	0.10	21.1	21.2	7.1	1.8	11.9	6.6	302.7	95.1	82.5	44.3	14.5	1.1	176.4	35.6	32.0	23.3
7.8	0.1	0.66	1.06	16.2	11.1	11.0	5.6	14.3	6.0	331.8	108.4	226.7	36.6	31.5	21.9	447.5	117.3	22.2	8.7
7.6	0.7	0.35	0.27	2.7	1.2	7.3	1.7	16.2	8.2	183.4	25.0	4.2	2.1	15.3	3.6	8.8	4.6	50.4	27.8
7.9	0.2	0.23	0.10	2.6	1.7	7.4	3.1	12.2	7.7	260.6	83.8	5.5	2.1	21.8	17.8	14.6	6.3	13.5	10.3
7.3	0.9	0.76	0.71	12.6	12.9	5.9	1.9	17.8	11.2	210.3	55.3	20.8	17.4	12.2	3.2	29.0	10.7	29.8	15.5
7.7	0.3	0.78	1.25	9.5	12.4	14.5	14.4	14.7	3.6	379.7	279.2	22.4	8.7	26.7	11.6	25.8	9.1	21.9	14.6
7.7	0.6	0.19	0.10	21.1	21.2	7.1	1.8	11.9	6.6	302.7	95.1	82.5	44.3	14.5	1.1	176.4	35.6	32.0	23.3
7.7	0.5	0.20	2.07	8.9	10.2	5.9	1.5	13.6	4.6	224.7	65.2	79.8	30.5	20.0	11.4	35.1	12.9	18.7	14.4
7.6	0.1	0.66	1.06	16.2	11.1	11.0	5.6	14.3	6.0	331.8	108.4	226.7	36.6	31.5	21.9	447.5	117.3	22.2	8.7
0.4		0.64		11.3		4.9		8.1		109.3		31.0		13.0		47.8		20.1	

Soil Analysis (15-30 cm)										Soil Analysis (30-60 cm)				Soil Analysis (60-120 cm)			
pH		E.C.		NO_3		NH_4		P		K		NO_3		NH_4		NO_3		NH_4	
7.9	0.2	0.55	0.51	2.5	1.4	5.5	1.4	15.6	7.5	246.4	77.6	4.7	2.3	27.1	24.9	7.9	5.2	17.5	12.6
7.6	0.7	0.35	0.27	2.7	1.2	7.3	1.7	16.2	8.2	183.4	25.0	4.2	2.1	15.3	3.6	8.8	4.6	50.4	27.8
7.3	0.9	0.76	0.71	12.6	12.9	5.9	1.9	17.8	11.2	210.3	55.3	20.8	17.4	12.2	3.2	29.0	10.7	29.8	15.5
8.1	0.5	0.23	0.06	4.0	1.3	8.6	2.1	22.9	11.8	203.3	64.0	21.9	5.8	18.0	2.1	37.0	25.8	27.4	4.7
7.9	0.3	0.74	0.59	2.7	0.9	6.0	2.1	16.3	9.7	216.8	49.3	5.0	1.4	16.5	2.2	10.1	5.5	17.2	12.4
7.8	0.6	0.19	0.05	2.7	1.4	7.5	1.8	14.3	7.9			6.1	2.4	14.6	2.2	23.5	8.3	49.1	44.5
7.6	0.7	0.35	0.27	2.7	1.2	7.3	1.7	16.2	8.2	183.4	25.0	4.2	2.1	15.3	3.6	8.8	4.6	50.4	27.8
7.3	0.9	0.76	0.71	12.6	12.9	5.9	1.9	17.8	11.2	210.3	55.3	20.8	17.4	12.2	3.2	29.0	10.7	29.8	15.5
7.7	0.6	0.19	0.10	21.1	21.2	7.1	1.8	11.9	6.6	302.7	95.1	82.5	44.3	14.5	1.1	176.4	35.6	32.0	23.3
7.8	0.1	0.66	1.06	16.2	11.1	11.0	5.6	14.3	6.0	331.8	108.4	226.7	36.6	31.5	21.9	447.5	117.3	22.2	8.7
7.9	0.2	0.55	0.51	2.5	1.4	5.5	1.4	15.6	7.5	246.4	77.6	4.7	2.3	27.1	24.9	7.9	5.2	17.5	12.6
8.0	0.5	0.20	0.04	3.7	1.1	6.9	1.7	17.2	11.4	205.1	46.4	20.0	11.1	14.4	3.9	22.4	12.0	23.8	7.7
7.5	0.9	0.93	0.97	7.1	4.1	11.1	5.4	21.6	11.3	173.0	37.4	25.3	9.2	14.5	2.4	54.1	18.2	26.2	4.2
7.5	0.8	0.30	0.18	21.8	20.4	6.6	1.8	12.0	5.8	200.7	43.6	115.8	70.8	23.5	7.2	329.9	86.2	38.0	26.5
7.9	0.2	0.55	0.51	2.5	1.4	5.5	1.4	15.6	7.5	246.4	77.6	4.7	2.3	27.1	24.9	7.9	5.2	17.5	12.6
7.6	0.7	0.35	0.27	2.7	1.2	7.3	1.7	16.2	8.2	183.4	25.0	4.2	2.1	15.3	3.6	8.8	4.6	50.4	27.8
7.7	0.3	0.78	1.25	9.5	12.4	14.5	14.4	14.7	3.6	379.7	279.2	22.4	8.7	26.7	11.6	25.8	9.1	21.9	14.6
7.8	0.2	0.66	1.07	9.5	7.6	7.4	2.7	14.0	4.1	261.3	42.1	42.8	37.2	21.2	5.7	24.9	15.3	25.2	19.4
7.7	0.6	0.19	0.10	21.1	21.2	7.1	1.8	11.9	6.6	302.7	95.1	82.5	44.3	14.5	1.1	176.4	35.6	32.0	23.3
0.4		0.64		11.3		4.9		8.1		109.3		31.0		13.0		47.8		20.1	

TABLE 1B Dixon Swine Site 2006 Yield, Crop, Soil Nutrients SUMMARY

2006 Linola (Flax) Crop Harvest

Combined Plots: Hog Manure and No Phos Plots with Hog Manure + Phosphorus Amended Plots

Rate of Manure Application-One Time

Trt	Rate 1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	N	Crop Harvest Fall 2006 kg / ha: Grain Yld No Phos		Grain Yld + Phos		Straw Yld No Phos		Straw Yld + Phos		Grain Sample N & P Analysis milligram / g: Grain N No Phos		Grain N + Phos		Grain P No Phos		Grain P + Phos		StrawSample N & P Analysis milligram/g: Straw N No Phos		Straw N + Phos		Straw P No Phos		Straw P + Phos	
2	0	0	0	0	0	0	0	0	0	0	4	996	192	970	187	1002	223	833	209	21.4	1.2	23.2	1.4	5.2	0.3	4.9	0.2	3.7	0.5	3.6	0.7	1.0	0.4	0.7	0.3
3	1	0	0	1	0	0	1	0	0	1	4	2243	537	2252	292	2507	1068	2051	308	23.2	0.8	25.8	1.3	4.0	0.3	3.8	0.2	4.3	0.4	4.0	0.9	0.5	0.3	0.4	0.1
5	2	0	0	2	0	0	2	0	0	2	4	2965	136	2768	251	3457	330	2882	333	25.5	0.5	27.5	2.3	3.4	0.4	3.5	0.3	4.0	0.4	4.2	0.8	0.2	0.1	0.3	0.1
8	4	0	0	4	0	0	4	0	0	4	4	2502	368	2199	378	2661	601	2453	691	26.0	0.3	28.6	1.7	3.7	0.3	3.5	0.3	5.2	0.6	4.7	0.2	0.3	0.1	0.2	0.1

Rate of Manure Application-Annual

Trt	Rate 1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	N	Crop Harvest Fall 2006 kg / ha: Grain Yld No Phos		Grain Yld + Phos		Straw Yld No Phos		Straw Yld + Phos		Grain Sample N & P Analysis milligram / g: Grain N No Phos		Grain N + Phos		Grain P No Phos		Grain P + Phos		StrawSample N & P Analysis milligram/g: Straw N No Phos		Straw N + Phos		Straw P No Phos		Straw P + Phos	
2	0	0	0	0	0	0	0	0	0	0	4	996	192	970	187	1002	223	833	209	21.4	1.2	23.2	1.4	5.2	0.3	4.9	0.2	3.7	0.5	3.6	0.7	1.0	0.4	0.7	0.3
4	1	1	1	1	1	1	1	1	1	1	4	2839	319	2364	234	3353	739	2606	585	26.6	0.9	28.4	2.2	3.7	0.3	3.5	0.2	4.9	1.1	4.5	1.3	0.4	0.2	0.3	0.2
7	2	2	2	2	2	2	2	2	2	2	4	3080	285	2504	356	3513	292	2912	768	28.2	2.6	27.5	1.5	3.6	0.2	3.3	0.4	5.1	0.5	5.3	1.0	0.2	0.1	0.2	0.1
9	4	4	4	4	4	4	4	4	4	4	4	2963	347	2384	239	3450	884	2424	505	28.6	2.5	29.1	1.8	3.5	0.6	3.1	0.2	6.9	1.9	6.1	0.8	0.2	0.1	0.2	0.0

Rate of Manure Application-Annual & Skipped

Trt	Rate 1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	N	Crop Harvest Fall 2006 kg / ha: Grain Yld No Phos		Grain Yld + Phos		Straw Yld No Phos		Straw Yld + Phos		Grain Sample N & P Analysis milligram / g: Grain N No Phos		Grain N + Phos		Grain P No Phos		Grain P + Phos		StrawSample N & P Analysis milligram/g: Straw N No Phos		Straw N + Phos		Straw P No Phos		Straw P + Phos	
2	0	0	0	0	0	0	0	0	0	0	4	996	192	970	187	1002	223	833	209	21.4	1.2	23.2	1.4	5.2	0.3	4.9	0.2	3.7	0.5	3.6	0.7	1.0	0.4	0.7	0.3
3	1	0	0	1	0	0	1	0	0	0	4	2243	537	2282	292	2507	1068	2051	308	23.2	0.8	25.8	1.3	4.0	0.3	3.8	0.2	4.3	0.4	4.0	0.9	0.5	0.3	0.4	0.1
4	1	1	1	1	1	1	1	1	1	1	4	2839	319	2364	234	3353	739	2606	585	26.6	0.9	28.4	2.2	3.7	0.3	3.5	0.2	4.9	1.1	4.5	1.3	0.4	0.2	0.3	0.2
5	2	0	0	2	0	0	2	0	0	2	4	2965	136	2768	251	3457	330	2882	333	25.5	0.5	27.5	2.3	3.4	0.4	3.5	0.3	4.0	0.4	4.2	0.8	0.2	0.1	0.3	0.1
7	2	2	2	2	2	2	2	2	2	2	4	3080	285	2504	356	3513	292	2912	768	28.2	2.6	27.5	1.5	3.6	0.2	3.3	0.4	5.1	0.5	5.3	1.0	0.2	0.1	0.2	0.1
8	4	0	0	4	0	0	4	0	0	0	4	2502	368	2199	378	2661	601	2453	691	26.0	0.3	28.6	1.7	3.7	0.3	3.5	0.3	5.2	0.6	4.7	0.2	0.3	0.1	0.2	0.1
9	4	4	4	4	4	4	4	4	4	4	4	2963	347	2384	239	3450	884	2424	505	28.6	2.5	29.1	1.6	3.5	0.6	3.1	0.2	6.9	1.9	6.1	0.8	0.2	0.1	0.2	0.0
LSD												384		347		696		598		1.4		1.8		0.4		0.3		1.0		1.0		0.2		0.1	

Method of Manure Application-Annual

Trt	Method	N	Crop Harvest Fall 2006: Grain Yld No Phos		Grain Yld + Phos		Straw Yld No Phos		Straw Yld + Phos		Grain Sample N & P Analysis: Grain N No Phos		Grain N + Phos		Grain P No Phos		Grain P + Phos		StrawSample N & P Analysis: Straw N No Phos		Straw N + Phos		Straw P No Phos		Straw P + Phos	
1	Control-Average	4	1049	227	844	184	1131	315	716	194	21.6	2.1	22.8	0.9	5.1	0.2	5.1	0.2	3.3	0.6	3.8	0.5	0.8	0.3	0.8	0.2
2	Control-Disturbed	4	996	192	970	187	1002	223	833	209	21.4	1.2	23.2	1.4	5.2	0.3	4.9	0.2	3.7	0.5	3.6	0.7	1.0	0.4	0.7	0.3
4	1X1X1X1X1X1X1X Injection @12	4	2839	319	2364	234	3353	739	2606	585	26.6	0.9	28.4	2.2	3.7	0.3	3.5	0.2	4.9	1.1	4.5	1.3	0.4	0.2	0.3	0.2
10	1X1X1X1X1X1X1X Injection @ 12" + INHIBITOR 05+06	4	2737	132	2115	257	3401	489	2468	364	27.3	2.2	28.6	2.9	3.6	0.5	3.5	0.4	3.9	0.4	3.9	0.7	0.2	0.1	0.2	0.1
11	1X1X1X1X1X1X1X + H2O	4	1096	205	1188	286	1187	287	1435	349	21.8	1.5	22.9	0.7	5.0	0.4	5.0	0.2	3.4	0.3	3.7	0.5	0.8	0.5	0.8	0.2
12	1X1X1X 1X1X1X1XBroadcast & Incorporated	4	2356	371	2059	261	2417	855	2220	456	25.1	1.6	26.2	1.9	4.0	0.5	4.0	0.4	4.4	0.7	3.8	1.2	0.5	0.2	0.3	0.1

Source and Rate of Annual N Application-Balanced

Trt		Rate 1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	N	Crop Harvest Fall 2006 kg / ha: Grain Yld No Phos		Grain Yld + Phos		Straw Yld No Phos		Straw Yld + Phos		Grain Sample N & P Analysis milligram / g: Grain N No Phos		Grain N + Phos		Grain P No Phos		Grain P + Phos		StrawSample N & P Analysis milligram/g: Straw N No Phos		Straw N + Phos		Straw P No Phos		Straw P + Phos	
2	Hog	0	0	0	0	0	0	0	0	0	0	4	996	192	970	187	1002	223	833	209	21.4	1.2	23.2	1.4	5.2	0.3	4.9	0.2	3.7	0.5	3.6	0.7	1.0	0.4	0.7	0.3
4	Hog	1	1	1	1	1	1	1	1	1	1	4	2839	319	2364	234	3353	739	2606	585	26.6	0.9	28.4	2.2	3.7	0.3	3.5	0.2	4.9	1.1	4.5	1.3	0.4	0.2	0.3	0.2
7	Hog	2	2	2	2	2	2	2	2	2	2	4	3080	285	2504	356	3513	292	2912	768	28.2	2.6	27.5	1.5	3.6	0.2	3.3	0.4	5.1	0.5	5.3	1.0	0.2	0.1	0.2	0.1
9	Hog	4	4	4	4	4	4	4	4	4	4	4	2963	347	2384	239	3450	884	2424	505	28.6	2.5	29.1	1.8	3.5	0.6	3.1	0.2	6.9	1.9	6.1	0.8	0.2	0.1	0.2	0.0
1	Hog	0	0	0	0	0	0	0	0	0	0	4	1049	227	844	184	1131	315	716	194	21.6	2.1	22.8	0.9	5.1	0.2	5.1	0.2	3.3	0.6	3.8	0.5	0.8	0.3	0.8	0.2
13	Urea	1	1	1	1	1	1	1	1	1	1	4	2312	640	2125	84	2885	555	2326	204	21.6	2.1	22.8	0.9	5.1	0.2	5.1	0.2	4.2	0.9	3.5	0.7	0.2	0.1	0.2	0.1
14	Urea	2	2	2	2	2	2	2	2	2	2	4	2463	603	2173	212	2723	353	2295	507	25.4	1.0	27.3	2.3	2.9	0.7	3.2	0.4	4.3	0.5	3.5	0.4	0.2	0.1	0.1	0.1
15	Urea	4	4	4	4	4	4	4	4	4	4	4	2668	332	2045	393	3108	610	2350	796	25.8	1.5	29.1	2.8	3.0	0.5	3.1	0.3	5.7	1.0	5.4	1.3	0.1	0.0	0.2	0.1

Alternating Hog Manure Application

Trt	Rate 1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	N	Crop Harvest Fall 2006 kg / ha: Grain Yld No Phos		Grain Yld + Phos		Straw Yld No Phos		Straw Yld + Phos		Grain Sample N & P Analysis: Grain N No Phos		Grain N + Phos		Grain P No Phos		Grain P + Phos		StrawSample N & P Analysis: Straw N No Phos		Straw N + Phos		Straw P No Phos		Straw P + Phos	
1	0	0	0	0	0	0	0	[illegible]	0	0	4	1049	227	844	184	1131	315	716	194	21.6	2.1	22.8	0.9	5.1	0.2	5.1	0.2	3.3	0.6	3.8	0.5	0.8	0.3	0.8	0.2
2	0	0	0	0	0	0	0	[illegible]	0	0	4	996	192	970	187	1002	223	833	209	21.4	1.2	23.2	1.4	5.2	0.3	4.9	0.2	3.7	0.5	3.6	0.7	1.0	0.4	0.7	0.3
5	2	0	0	2	0	0	2	[illegible]	0	2	4	2965	136	2768	251	3457	330	2582	333	25.5	0.5	27.5	2.3	3.4	0.4	3.5	0.3	4.0	0.4	4.2	0.8	0.2	0.1	0.3	0.1
6	2	0	0	2	2	0	0	2	2	2	4	2877	319	2347	539	3596	533	2436	903	26.1	1.3	27.2	2.6	3.4	0.3	3.3	0.2	4.8	0.9	4.6	1.2	0.2	0.2	0.2	0.1
7	2	2	2	2	2	2	2	2	2	2	4	3080	285	2504	356	3513	292	2912	768	28.2	2.6	27.5	1.5	3.6	0.2	3.3	0.4	5.1	0.5	5.3	1.0	0.2	0.1	0.2	0.1
LSD												384		347		696		598		1.4		1.8		0.4		0.3		1.0		1.0		0.2		0.1	

Note 1: Crop harvest (grain and straw yields) means in kg/ha
2: Grain and Straw Total N and Total P means in mg/g
3: Soil Extractable NH4, NO3, P & K means in kg/ha
4: Electrical conductivity means in mS/cm
5: Soil analysis conducted on Fall 2006 samples
6: Phosphorus was added in Fall 2005 at a rate of 30kg/ha of 11-51-0
7: Means in the first column are followed by standard deviations in the second column
8: N=Number of observations
9: LSD (0.10) calculated at p = 0.10

Soil Analysis (0-15 cm) kg/ha

NO_3 No Phos		NO_3 + Phos		NH_4 No Phos		NH_4 + Phos		P No Phos		P + Phos		K No Phos		K + Phos	
5.1	0.5	4.5	1.5	4.6	1.0	7.6	2.6	21.0	5.8	25.2	3.6	627.3	151.2	532.3	148.6
5.6	0.9	4.9	1.3	4.0	0.8	5.6	1.4	17.9	4.1	24.2	4.5	778.1	286.9	602.4	182.5
6.9	1.1	6.3	0.9	6.3	1.5	7.2	1.1	18.0	5.9	25.4	12.2	863.9	155.7	598.8	272.8
11.3	6.8	7.3	3.1	7.4	5.1	6.4	2.3	24.4	11.3	31.4	15.1	992.8	239.3	909.0	240.5
5.1	0.5	4.5	1.5	4.6	1.0	7.6	2.6	21.0	5.8	25.2	3.6	627.3	151.2	532.3	148.6
6.4	1.1	12.6	11.5	4.4	0.8	7.4	2.4	22.8	10.7	26.5	6.0	874.5	284.1	719.6	129.5
15.8	11.3	7.7	3.3	5.9	1.7	7.0	1.5	24.2	6.9	31.0	8.9	1259.6	341.9	978.1	202.3
17.9	15.1	7.4	2.4	5.0	1.0	7.9	1.2	48.0	20.1	54.0	10.3	1404.3	271.6	1322.7	120.2
5.1	0.5	4.5	1.5	4.6	1.0	7.9	2.6	21.0	5.8	25.2	3.6	627.3	151.2	532.3	148.6
5.6	0.9	4.9	1.3	4.0	0.8	5.6	1.4	17.9	4.1	24.2	4.5	778.1	286.9	602.4	182.5
6.4	1.1	12.6	11.5	4.4	0.8	7.4	2.4	22.8	10.7	26.5	6.0	874.5	284.1	719.6	129.5
6.9	1.1	6.3	0.9	6.3	1.5	7.2	1.1	16.0	5.9	25.4	12.2	863.9	155.7	598.8	272.8
15.8	11.3	7.7	3.3	5.9	1.7	7.0	1.5	24.2	6.9	31.0	8.9	1259.6	341.9	978.1	202.3
11.3	6.8	7.3	3.1	7.4	5.1	6.4	2.3	24.4	11.3	31.4	15.1	992.8	239.3	909.0	240.5
17.9	15.1	7.4	2.4	5.0	1.0	7.9	1.2	48.0	20.1	54.0	10.3	1404.3	271.6	1322.7	120.2
9.4		10.1		2.3		2.1		8.3		11.9		224.5		192.0	

Soil Analysis (0-15 cm)

NO_3 No Phos		NO_3 + Phos		NH_4 No Phos		NH_4 + Phos		P No Phos		P + Phos		K No Phos		K + Phos	
5.5	0.9	3.2	1.2	5.2	2.1	5.5	1.1	22.3	7.8	29.6	17.9	686.2	174.7	465.9	150.1
5.1	0.5	4.5	1.5	4.6	1.0	7.6	2.6	21.0	5.8	25.2	3.6	627.3	151.2	532.3	148.6
6.4	1.1	12.6	11.5	4.4	0.8	7.4	2.4	22.8	10.7	26.5	6.0	874.5	284.1	719.6	129.5
6.0	0.8	5.7	1.0	4.0	1.3	7.8	1.9	23.2	13.9	22.1	4.8	622.0	281.1	652.0	89.8
5.4	0.4	3.6	0.4	5.7	0.6	6.0	2.3	19.9	6.4	20.7	7.6	771.8	187.3	570.8	106.6
5.5	0.5	4.4	0.9	6.1	2.5	7.5	1.7	18.2	5.1	18.8	3.8	963.3	156.1	678.2	161.9
5.1	0.5	4.5	1.5	4.6	1.0	7.6	2.6	21.0	5.8	25.2	3.6	627.3	151.2	532.3	148.6
6.4	1.1	12.6	11.5	4.4	0.8	7.4	2.4	22.8	10.7	26.5	6.0	874.5	284.1	719.6	129.5
15.8	11.3	7.7	3.3	5.9	1.7	7.0	1.5	24.2	6.9	31.0	8.9	1259.6	341.9	978.1	202.3
17.9	15.1	7.4	2.4	5.0	1.0	7.9	1.2	48.0	20.1	54.0	10.3	1404.3	271.6	1322.7	120.2
5.5	0.9	3.2	1.2	5.2	2.1	5.5	1.1	22.3	7.8	29.6	17.9	686.2	174.7	465.9	150.1
8.6	5.9	4.5	0.4	5.5	1.1	8.0	0.6	16.3	5.7	16.2	2.7	498.9	33.4	579.3	126.1
6.9	3.5	4.0	1.0	5.2	1.6	8.6	1.4	12.5	1.9	16.1	2.5	529.1	107.6	477.6	115.5
8.7	2.3	22.7	30.5	6.2	0.4	10.9	4.8	14.7	3.2	21.2	0.6	657.3	212.8	434.5	61.7
5.5	0.9	3.2	1.2	5.2	2.1	5.5	1.1	22.3	7.8	29.6	17.9	686.2	174.7	465.9	150.1
5.1	0.5	4.5	1.5	4.6	1.0	7.6	2.6	21.0	5.8	25.2	3.6	627.3	151.2	532.3	148.6
6.9	1.1	6.3	0.9	6.3	1.5	7.2	1.1	18.0	5.9	25.4	12.2	863.9	155.7	598.8	272.8
18.0	20.4	6.5	3.2	6.3	1.1	7.3	2.0	17.8	0.7	28.9	24.4	848.3	307.6	664.0	343.6
15.8	11.3	7.7	3.3	5.9	1.7	7.0	1.5	24.2	6.9	31.0	8.9	1259.6	341.9	978.1	202.3
9.4		10.1		2.3		2.1		8.3		11.9		224.5		192.0	

Soil Analysis (15-30 cm) kg/ha

NO_3 No Phos		NO_3 + Phos		NH_4 No Phos		NH_4 + Phos		P No Phos		P + Phos		K No Phos		K + Phos	
3.9	0.5	2.7	1.2	5.8	0.8	7.3	1.7	13.6	5.1	18.2	8.2	307.7	89.4	183.4	25.0
4.4	0.3	2.8	1.7	5.5	1.4	7.4	3.1	11.1	3.4	12.2	7.7	328.5	103.8	260.8	83.8
7.7	4.8	9.5	12.4	6.5	1.0	14.5	14.4	8.4	0.9	14.7	3.6	285.8	30.4	379.7	279.2
16.7	16.9	8.9	10.2	5.3	1.1	5.9	1.5	8.3	1.8	13.6	4.6	269.9	102.8	224.7	65.2
3.9	0.5	2.7	1.2	5.8	0.8	7.3	1.7	13.6	5.1	18.2	8.2	307.7	89.4	183.4	25.0
5.6	2.9	12.6	12.9	5.3	1.8	5.9	1.9	13.1	6.7	17.8	11.2	260.7	104.3	210.3	55.3
17.0	23.4	21.1	21.2	5.8	0.4	7.1	1.8	11.1	1.3	11.9	6.6	348.5	93.7	302.7	95.1
59.1	89.4	16.2	11.1	4.3	0.9	11.0	5.6	12.4	5.5	14.3	6.0	329.7	69.2	331.8	108.4
3.9	0.5	2.7	1.2	5.8	0.8	7.3	1.7	13.6	5.1	18.2	8.2	307.7	89.4	183.4	25.0
4.4	0.3	2.8	1.7	5.5	1.4	7.4	3.1	11.1	3.4	12.2	7.7	328.5	103.8	260.8	83.8
5.6	2.9	12.6	12.9	5.3	1.8	5.9	1.9	13.1	6.7	17.8	11.2	260.7	104.3	210.3	55.3
7.7	4.8	9.5	12.4	6.5	1.0	14.5	14.4	8.4	0.9	14.7	3.6	285.8	30.4	379.7	279.2
17.0	23.4	21.1	21.2	5.8	0.4	7.1	1.8	11.1	1.3	11.9	6.6	348.5	93.7	302.7	95.1
16.7	16.9	8.9	10.2	5.3	1.1	5.9	1.5	8.3	1.8	13.6	4.6	269.9	102.8	224.7	65.2
59.1	89.4	16.2	11.1	4.3	0.9	11.0	5.6	12.4	5.5	14.3	6.0	329.7	69.2	331.8	108.4
31.5		11.3		1.5		4.9		6.4		8.1		85.0		109.0	

Soil Analysis (15-30 cm)

NO_3 No Phos		NO_3 + Phos		NH_4 No Phos		NH_4 + Phos		P No Phos		P + Phos		K No Phos		K + Phos	
4.4	0.3	2.5	1.4	4.9	2.6	5.5	1.4	12.0	3.5	15.6	7.5	268.1	55.2	246.4	77.6
3.9	0.5	2.7	1.2	5.8	0.8	7.3	1.7	13.6	5.1	18.2	8.2	307.7	89.4	183.4	25.0
5.6	2.9	12.6	12.9	5.3	1.8	5.9	1.9	13.1	6.7	17.8	11.2	260.7	104.3	210.3	55.3
4.7	0.4	4.0	1.3	5.2	1.2	8.6	2.1	11.2	4.4	22.9	11.8	274.3	81.2	178.8	75.0
4.3	0.4	2.7	0.9	6.4	1.1	6.0	2.1	10.0	1.6	16.3	6.7	318.7	80.3	203.3	64.0
3.8	0.3	2.7	1.4	6.3	1.6	7.5	1.8	9.6	1.1	14.3	7.9	298.4	91.3	216.8	49.3
3.9	0.5	2.7	1.2	5.8	0.8	7.3	1.7	13.6	5.1	18.2	8.2	307.7	89.4	183.4	25.0
5.6	2.9	12.6	12.9	5.3	1.8	5.9	1.9	13.1	6.7	17.8	11.2	260.7	104.3	210.3	55.3
17.0	23.4	21.1	21.2	5.8	0.4	7.1	1.8	11.1	1.3	11.9	6.6	348.5	93.7	302.7	95.1
59.1	89.4	16.2	11.1	4.3	0.9	11.0	5.6	12.4	5.5	14.3	6.0	329.7	69.2	331.8	108.4
4.4	0.3	2.5	1.4	4.9	2.6	5.5	1.4	12.0	3.5	15.6	7.5	268.1	55.2	246.4	77.6
17.2	9.8	3.7	1.1	5.9	1.8	6.9	1.7	12.1	2.9	17.2	11.4	231.5	20.5	205.1	46.4
21.2	32.6	7.1	4.1	6.1	0.7	11.1	5.4	16.0	12.6	21.6	11.3	251.7	78.1	173.0	37.4
19.0	11.4	21.8	20.4	5.8	1.8	6.6	1.8	9.1	1.6	12.0	5.8	282.4	35.9	260.7	43.6
4.4	0.3	2.5	1.4	4.9	2.6	5.5	1.4	12.0	3.5	15.6	7.5	268.1	55.2	246.4	77.6
3.9	0.5	2.7	1.2	5.8	0.8	7.3	1.7	13.6	5.1	18.2	8.2	307.7	89.4	183.4	25.0
7.7	4.8	9.5	12.4	6.5	1.0	14.5	14.4	8.4	0.9	14.7	3.6	285.8	30.4	379.7	279.2
43.0	30.4	9.3	7.6	6.1	0.7	7.4	2.7	13.6	10.3	14.0	4.1	261.0	122.7	261.3	42.1
17.0	23.4	21.1	21.2	5.8	0.4	7.1	1.8	11.1	1.3	11.9	6.6	348.5	93.7	302.7	95.1
31.5		11.3		1.5		4.9		6.4		8.1		85.0		109.0	

Soil Analysis (30-60 cm) kg/ha					
NO_3		NH_4		NH_4	
+ Phos		No Phos		+ Phos	
4.2	2.1	25.1	19.4	15.3	3.6
5.5	2.1	15.8	10.4	21.8	17.8
22.4	8.7	13.0	3.3	26.7	11.6
79.8	30.5	7.6	2.7	20.0	11.4
4.2	2.1	25.1	19.4	15.3	3.6
20.8	17.4	14.0	1.1	12.2	3.2
82.5	44.3	19.9	12.1	14.5	1.1
226.7	36.6	26.4	33.1	31.5	21.9
4.2	2.1	25.1	19.4	15.3	3.6
5.5	2.1	15.8	10.4	21.8	17.8
20.8	17.4	14.0	1.1	12.2	3.2
22.4	8.7	13.0	3.3	26.7	11.6
82.5	44.3	19.9	12.1	14.5	1.1
79.8	30.5	7.6	2.7	20.0	11.4
226.7	36.6	26.4	33.1	31.5	21.9
31.0		15.1		13.0	

Soil Analysis (60-120 cm)					
NO_3	NO_3		NH_4	NH_4	
No Phos	+ Phos		No Phos	+ Phos	
	8.8	4.6		50.4	27.8
	14.6	6.3		13.5	10.3
	25.8	9.1		21.9	14.6
	35.1	12.9		18.7	14.4
	8.8	4.6		50.4	27.8
	29.0	10.7		29.8	15.5
	176.4	35.6		32.0	23.3
	447.5	117.3		22.2	8.7
	8.8	4.6		50.4	27.8
	14.6	6.3		13.5	10.3
	29.0	10.7		29.8	15.5
	25.8	9.1		21.9	14.6
	176.4	35.6		32.0	23.3
	35.1	12.9		18.7	14.4
	447.5	117.3		22.2	8.7
	47.8			20.1	

Soil Analysis (30-60 cm)					
NO_3		NH_4		NH_4	
+ Phos		No Phos		+ Phos	
4.7	2.3	11.4	3.7	27.1	24.9
4.2	2.1	25.1	19.4	15.3	3.6
20.8	17.4	14.0	1.1	12.2	3.2
21.9	5.8	20.4	21.9	18.0	2.1
5.0	1.4	13.0	5.6	19.5	2.2
6.1	2.4	15.7	6.2	14.6	2.2
4.2	2.1	25.1	19.4	15.3	3.6
20.8	17.4	14.0	1.1	12.2	3.2
82.5	44.3	19.9	12.1	14.5	1.1
226.7	36.6	26.4	33.1	31.5	21.9
4.7	2.3	11.4	3.7	27.1	24.9
20.0	11.1	10.2	5.7	14.4	3.9
25.3	9.2	15.1	10.8	14.5	2.4
115.8	70.8	14.0	8.0	23.5	7.2
4.7	2.3	11.4	3.7	27.1	24.9
4.2	2.1	25.1	19.4	15.3	3.6
22.4	8.7	13.0	3.3	26.7	11.6
42.8	37.2	9.4	1.4	21.2	5.7
82.5	44.3	19.9	12.1	14.5	1.1
31.0		15.1		13.0	

Soil Analysis (60-120 cm)					
NO_3	NO_3		NH_4	NH_4	
No Phos	+ Phos		No Phos	+ Phos	
	7.9	5.2		17.5	12.6
	8.8	4.6		50.4	27.8
	29.0	10.7		29.8	15.5
	37.0	25.8		27.4	4.7
	10.1	5.5		17.3	12.4
	23.5	8.3		49.1	44.5
	8.8	4.6		50.4	27.8
	29.0	10.7		29.8	15.5
	176.4	35.6		32.0	23.3
	447.5	117.3		22.2	8.7
	7.9	5.2		17.5	12.6
	22.4	12.0		23.8	7.7
	54.1	18.2		26.2	4.2
	529.9	86.2		38.0	26.5
	7.9	5.2		17.5	12.6
	8.8	4.6		50.4	27.8
	25.8	9.1		21.9	14.6
	24.9	15.3		25.2	19.4
	176.4	35.6		32.0	23.3
	47.8			20.1	

TABLE 2B. Dixon Cattle Manure Site 2006 Yield, Crop and Soil Nutrients

2006 Linola (Flax) Crop Harvest

Cattle Manure Ammended Plots

Rate of Manure Application One Time

Trt	Rate 1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	N	Crop Harvest 2006 kg/ha: Grain Yld		Straw Yld		Crop Sample N & P Analysis milligrams / g plant: Grain N		Straw N		Grain P		Straw P		Soil Analysis (0-15 cm) kg/ha: pH		E.C.		NO_3		NH_4		P		K	
1	0	0	0	0	0	0	0	0	0	0	4	1232	142	1386	115	22.4	0.6	3.3	0.3	5.4	0.0	1.0	0.1	7.9	0.1	0.29	0.06	2.8	0.8	7.1	3.3	29.8	5.7	691.1	82.1
2	1	0	0	1	0	0	1	0	0	1	4	1134	69	1399	339	22.5	1.3	3.6	0.4	5.3	0.2	1.2	0.2	7.8	0.2	0.37	0.18	2.2	0.7	4.4	2.8	30.4	6.2	798.4	79.6
3	1	1	1	1	1	1	1	1	1	1	4	1274	355	1551	677	22.8	1.3	4.6	1.0	5.3	0.2	1.4	0.2	7.9	0.0	0.33	0.11	3.3	0.8	6.6	1.8	61.6	26.7	1207.7	197.9
4	2	0	0	2	0	0	2	0	0	2	4	1456	152	1504	113	22.1	0.3	3.7	0.3	5.2	0.2	1.2	0.2	7.8	0.1	0.33	0.20	3.7	0.8	5.8	2.0	53.1	12.7	1114.7	134.4
5	2	2	2	2	2	2	2	2	2	2	4	1675	215	2400	695	23.1	1.0	4.0	1.0	5.2	0.2	1.2	0.3	7.9	0.1	0.46	0.15	3.6	1.0	5.1	2.1	78.2	28.6	1300.8	189.2
6	4	4	4	4	4	4	4	4	4	4	4	1694	385	2049	274	23.1	1.7	4.1	0.7	5.0	0.4	1.1	0.2	7.9	0.2	0.27	0.06	3.4	0.6	3.8	1.2	79.7	37.5	1372.8	231.0
7	4	0	0	4	0	0	4	0	0	4	4	2443	489	3083	311	27.6	3.5	4.0	0.6	4.8	0.2	0.8	0.1	8.0	0.2	0.43	0.17	5.1	1.0	8.2	5.3	177.4	26.4	2276.6	240.7

Rate of Manure Application-Annual

Trt	Rate 1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	N	Crop Harvest 2006 kg/ha: Grain Yld		Straw Yld		Crop Sample N & P Analysis milligrams / g plant: Grain N		Straw N		Grain P		Straw P		Soil Analysis (0-15 cm) kg/ha: pH		E.C.		NO_3		NH_4		P		K	
1	0	0	0	0	0	0	0	0	0	0	4	1232	142	1386	115	22.4	0.6	3.3	0.3	5.4	0.0	1.0	0.1	7.9	0.1	0.29	0.06	2.8	0.8	7.1	3.3	29.8	5.7	691.1	82.1
3	1	1	1	1	1	1	1	1	1	1	4	1274	355	1551	677	22.8	1.3	4.6	1.0	5.3	0.2	1.4	0.2	7.9	0.0	0.33	0.11	3.3	0.8	6.6	1.8	61.6	26.7	1207.7	197.9
6	2	2	2	2	2	2	2	2	2	2	4	1675	215	2400	695	23.1	1.0	4.0	1.0	5.2	0.2	1.2	0.3	7.9	0.1	0.46	0.15	3.6	1.0	5.1	2.1	78.2	28.6	1300.8	189.2
8	4	4	4	4	4	4	4	4	4	4	4	2443	489	3083	311	27.6	3.5	4.0	0.6	4.8	0.2	0.8	0.1	8.0	0.2	0.43	0.17	5.1	1.0	8.2	5.3	177.4	26.4	2276.6	240.7

Rate of Manure Application-Annual & Skipped

Trt	Rate 1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	N	Crop Harvest 2006 kg/ha: Grain Yld		Straw Yld		Crop Sample N & P Analysis milligrams / g plant: Grain N		Straw N		Grain P		Straw P		Soil Analysis (0-15 cm) kg/ha: pH		E.C.		NO_3		NH_4		P		K	
1	0	0	0	0	0	0	0	0	0	0	4	1232	142	1386	115	22.4	0.6	3.3	0.3	5.4	0.0	1.0	0.1	7.9	0.1	0.29	0.06	2.8	0.8	7.1	3.3	29.8	5.7	691.1	82.1
2	1	0	0	1	0	0	1	0	0	0	4	1134	69	1399	339	22.5	1.3	3.6	0.4	5.3	0.2	1.2	0.2	7.8	0.2	0.37	0.18	2.2	0.7	4.4	2.8	30.4	6.2	798.4	79.6
3	1	1	1	1	1	1	1	1	1	1	4	1274	355	1551	677	22.8	1.3	4.6	1.0	5.3	0.2	1.4	0.2	7.9	0.0	0.33	0.11	3.3	0.8	6.6	1.8	61.6	26.7	1207.7	197.9
4	2	0	0	2	0	0	2	0	0	2	4	1456	152	1504	113	22.1	0.3	3.7	0.3	5.2	0.2	1.2	0.2	7.8	0.1	0.33	0.20	3.7	0.8	5.8	2.0	53.1	12.7	1114.7	134.4
5	2	2	2	2	2	2	2	2	2	2	4	1675	215	2400	695	23.1	1.0	4.0	1.0	5.2	0.2	1.2	0.3	7.9	0.1	0.46	0.15	3.6	1.0	5.1	2.1	78.2	28.6	1300.8	189.2
6	4	4	4	4	4	4	4	4	4	4	4	1694	385	2049	274	23.1	1.7	4.1	0.7	5.0	0.4	1.1	0.2	7.9	0.2	0.27	0.06	3.4	0.6	3.8	1.2	79.7	37.5	1372.8	231.0
7	4	0	0	4	0	0	4	0	0	4	4	2443	489	3083	311	27.6	3.5	4.0	0.6	4.8	0.2	0.8	0.1	8.0	0.2	0.43	0.17	5.1	1.0	8.2	5.3	177.4	26.4	2276.6	240.7
8	4	4	4	4	4	4	4	4	4	4																								
LSD												426		564		1.9		0.6		0.3		0.2		0.3		0.15		9.8		3.7		23.5		204.5	

Incorporation Timing - Annual

Trt	Method	N	Crop Harvest Fall 2006: Grain Yld		Straw Yld		Crop Sample N & P Analysis: Grain N		Straw N		Grain P		Straw P		Soil Analysis (0-15 cm): pH		E.C.		NO_3		NH_4		P		K	
1	0X0X0X0X0X0X0X Control with Incorp	4	1232	142	1386	115	22.4	0.6	3.3	0.3	5.4	0.0	1.0	0.1	7.9	0.1	0.29	0.06	2.8	0.8	7.1	3.3	29.8	5.7	691.1	82.1
3	1X1X1X 1X1X1X1X Broadcast & Incorporated	4	1274	355	1551	677	22.8	1.3	4.6	1.0	5.3	0.2	1.4	0.2	7.9	0.0	0.33	0.11	3.3	0.8	6.6	1.8	61.6	26.7	1207.7	197.9
9	1X1X1X 1X1X1X1X Broadcast/Delayed Incorp	4	1173	126	1430	482	22.8	0.6	4.6	0.6	5.3	0.2	1.2	0.2	7.9	0.2	0.30	0.13	3.5	0.7	6.5	2.9	40.9	16.3	892.4	61.6

Source and Rate of Annual N Application-Balanced

Trt	Rate 1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	N	Crop Harvest 2006 kg/ha: Grain Yld		Straw Yld		Crop Sample N & P Analysis milligrams / g plant: Grain N		Straw N		Grain P		Straw P		Soil Analysis (0-15 cm) kg/ha: pH		E.C.		NO_3		NH_4		P		K	
1	Cntl	0	0	0	0	0	0	0	0	0	0	4	1232	142	1386	115	22.4	0.6	3.3	0.3	5.4	0.0	1.0	0.1	7.9	0.1	0.29	0.06	2.8	0.8	7.1	3.3	29.8	5.7	691.1	82.1
3	Cattle	1	1	1	1	1	1	1	1	1	1	4	1274	355	1551	677	22.8	1.3	4.6	1.0	5.3	0.2	1.4	0.2	7.9	0.0	0.33	0.11	3.3	0.8	6.6	1.8	61.6	26.7	1207.7	197.9
6	Cattle	2	2	2	2	2	2	2	2	2	2	4	1675	215	2400	695	23.1	1.0	4.0	1.0	5.2	0.2	1.2	0.3	7.9	0.1	0.46	0.15	3.6	1.0	5.1	2.1	78.2	28.6	1300.8	189.2
8	Cattle	4	4	4	4	4	4	4	4	4	4	4	2443	489	3083	311	27.6	3.5	4.0	0.6	4.8	0.2	0.8	0.1	8.0	0.2	0.43	0.17	5.1	1.0	8.2	5.3	177.4	26.4	2276.6	240.7
10	Urea	1	1	1	1	1	1	1	1	1	1	4	2304	286	2776	472	25.6	1.8	4.7	0.3	3.5	0.5	0.4	0.1	7.9	0.4	0.22	0.03	6.0	2.3	11.0	5.3	21.0	2.7	600.1	150.3
11	Urea	2	2	2	2	2	2	2	2	2	2	4	2278	702	2685	744	27.6	1.1	4.9	0.5	3.9	0.0	0.4	0.0	7.8	0.4	0.27	0.10	9.6	7.7	9.0	2.0	24.3	7.0	687.6	140.7
12	Urea	4	4	4	4	4	4	4	4	4	4	4	2265	472	3113	541	28.6	2.1	6.7	0.5	3.4	0.4	0.3	0.2	7.5	0.7	0.28	0.17	22.1	27.9	6.2	2.2	25.3	2.8	616.3	155.4

Alternating Cattle Manure Application

Trt	Rate 1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	N	Crop Harvest 2006 kg/ha: Grain Yld		Straw Yld		Crop Sample N & P Analysis milligrams / g plant: Grain N		Straw N		Grain P		Straw P		Soil Analysis (0-15 cm) kg/ha: pH		E.C.		NO_3		NH_4		P		K	
1	0	0	0	0	0	0	0	0	0	0	4	1232	142	1386	115	22.4	0.6	3.3	0.3	5.4	0.0	1.0	0.1	7.9	0.1	0.29	0.06	2.8	0.8	7.1	3.3	29.8	5.7	691.1	82.1
4	2	0	0	2	0	0	2	0	0	2	4	1456	152	1504	113	22.1	0.3	3.7	0.3	5.2	0.2	1.2	0.2	7.8	0.1	0.33	0.20	3.7	0.8	5.8	2.0	53.1	12.7	1114.7	134.4
5	2	0	2	2	0	2	2	0	2	2	4	1435	510	1698	437	23.1	1.0	4.0	1.0	5.2	0.2	1.2	0.3	7.8	0.2	0.34	0.11	4.7	1.3	9.0	4.3	58.3	18.3	1200.9	214.0
6	2	2	2	2	2	2	2	2	2	2	4	1675	215	2400	695	23.1	1.0	4.0	1.0	5.2	0.2	1.2	0.3	7.9	0.1	0.46	0.15	3.6	1.0	5.1	2.1	78.2	28.6	1300.8	189.2
LSD												426		564		1.9		0.6		0.3		0.2		0.3		0.15		9.8		3.7		23.5		204.5	

Note 1 Crop harvest (grain and straw yields) means in kg ha^{-1}
2 Grain and Straw Total N and Total P means in mg g^{-1}
3 Soil Extractable NH_4, NO_3, P & K means in kg ha^{-1}
4 Electrical conductivity means in mS cm^{-1}
5 Soil analysis conducted on Fall 2006 samples
6 Means in the first column are followed by standard deviations in the second column
7 N=Number of observations
8 LSD (0.10) calculated at p = 0.10

Soil Analysis (15-30 cm) kg/ha											Soil Analysis (30-60 cm) kg/ha				Soil Analysis (60-120 cm) kg/ha			
pH		E C		NO_3		NH_4		P		K	NO_3		NH_4		NO_3		NH_4	
7.7	0.2	0.35	0.34	2.5	1.6	9.1	2.7	22.4	15.6	264.1	2.0	0.9	14.4	7.4	2.8	1.5	28.8	21.6
7.7	0.4	0.16	0.05	1.5	0.8	5.9	2.4	14.9	5.8	250.6	1.7	1.3	23.7	24.9	1.8	1.7	30.8	31.9
7.8	0.1	0.30	0.30	1.8	1.0	6.0	1.4	15.0	2.7	316.0	2.1	1.0	18.3	13.4	3.1	1.8	49.0	35.1
7.8	0.2	0.47	0.38	1.5	0.8	3.5	1.5	14.4	2.8	216.0	2.1	0.7	8.6	6.2	4.5	3.2	14.3	12.3
7.7	0.2	0.35	0.34	2.5	1.6	9.1	2.7	22.4	15.6	264.1	2.0	0.9	14.4	7.4	2.8	1.5	28.8	21.6
7.8	0.2	0.31	0.27	1.9	1.0	7.1	2.2	14.7	2.4	314.6	2.4	0.7	11.2	5.1	2.8	1.7	29.8	21.8
7.8	0.1	0.40	0.38	1.9	0.7	8.0	6.9	20.3	5.1	276.4	2.9	1.5	8.5	4.5	5.4	3.6	18.3	11.4
7.9	0.3	0.50	0.26	2.8	1.3	5.1	2.5	44.0	39.7	537.6	6.0	4.1	9.6	7.4	21.1	24.1	25.8	21.2
7.7	0.2	0.35	0.34	2.5	1.6	9.1	2.7	22.4	15.6	264.1	2.0	0.9	14.4	7.4	2.8	1.5	28.8	21.6
7.7	0.4	0.16	0.05	1.5	0.8	5.9	2.4	14.9	5.8	250.6	1.7	1.3	23.7	24.9	1.8	1.7	30.8	31.9
7.8	0.2	0.31	0.27	1.9	1.0	7.1	2.2	14.7	2.4	314.6	2.4	0.7	11.2	5.1	2.8	1.7	29.8	21.8
7.8	0.1	0.30	0.30	1.8	1.0	6.0	1.4	15.0	2.7	316.0	2.1	1.0	18.3	13.4	3.1	1.8	49.0	35.1
7.8	0.1	0.40	0.38	1.9	0.7	8.0	6.9	20.3	5.1	276.4	2.9	1.5	8.5	4.5	5.4	3.6	18.3	11.4
7.8	0.2	0.47	0.38	1.5	0.8	3.5	1.5	14.4	2.8	216.0	2.1	0.7	8.6	6.2	4.5	3.2	14.3	12.3
7.9	0.3	0.50	0.26	2.8	1.3	5.1	2.5	44.0	39.7	537.6	6.0	4.1	9.6	7.4	21.1	24.1	25.8	21.2
0.2		0.35		12.4		6.1		17.4		135.1	24.9		13.9		46.7		24.8	

Soil Analysis (15-30 cm)											Soil Analysis (30-60 cm)				Soil Analysis (60-120 cm)			
pH		E C		NO_3		NH_4		P		K	NO_3		NH_4		NO_3		NH_4	
7.7	0.2	0.35	0.34	2.5	1.6	9.1	2.7	22.4	15.6	264.1	2.0	0.9	14.4	7.4	2.8	1.5	28.8	21.6
7.8	0.2	0.31	0.27	1.9	1.0	7.1	2.2	14.7	2.4	314.6	2.4	0.7	11.2	5.1	2.8	1.7	29.8	21.8
7.9	0.1	0.44	0.35	1.8	0.7	5.6	2.3	21.5	13.0	254.3	2.8	1.2	19.8	15.2	4.9	2.1	9.9	1.7
7.7	0.2	0.35	0.34	2.5	1.6	9.1	2.7	22.4	15.6	264.1	2.0	0.9	14.4	7.4	2.8	1.5	28.8	21.6
7.8	0.2	0.31	0.27	1.9	1.0	7.1	2.2	14.7	2.4	314.6	2.4	0.7	11.2	5.1	2.8	1.7	29.8	21.8
7.8	0.1	0.40	0.38	1.9	0.7	8.0	6.9	20.3	5.1	276.4	2.9	1.5	8.5	4.5	5.4	3.6	18.3	11.4
7.9	0.3	0.50	0.26	2.8	1.3	5.1	2.5	44.0	39.7	537.6	6.0	4.1	9.6	7.4	21.1	24.1	25.8	21.2
7.9	0.3	0.41	0.20	8.3	4.1	11.6	4.8	16.6	8.6	257.5	5.9	3.1	18.5	12.7	7.1	3.5	17.0	7.8
7.9	0.3	0.35	0.27	10.0	9.3	7.2	3.7	12.9	4.6	225.0	30.8	23.0	15.0	7.3	34.0	12.7	24.4	18.5
7.6	0.2	0.27	0.17	63.8	34.2	7.3	2.6	22.1	10.4	250.1	221.2	66.4	11.0	3.3	291.8	135.3	22.4	20.1
7.7	0.2	0.35	0.34	2.5	1.6	9.1	2.7	22.4	15.6	264.1	2.0	0.9	14.4	7.4	2.8	1.5	28.8	21.6
7.8	0.1	0.30	0.30	1.8	1.0	6.0	1.4	15.0	2.7	316.0	2.1	1.0	18.3	13.4	3.1	1.8	49.0	35.1
7.7	0.1	0.37	0.32	1.4	0.9	12.6	14.3	16.4	10.3	255.0	2.0	0.9	21.9	22.9	8.8	12.4	31.4	21.0
7.8	0.1	0.40	0.38	1.9	0.7	8.0	6.9	20.3	5.1	276.4	2.9	1.5	8.5	4.5	5.4	3.6	18.3	11.4
0.2		0.35		12.4		6.1		17.4		135.1	24.9		13.9		46.7		24.8	

TABLE 3B. Melfort Swine Manure Site 2006 Yield, Crop, Soil Results

2006 Barley Crop Harvest

Manure Rate

Trt	Rate 2000	2001	2002	2003	2004	2005	2006
1	0	0	0	0	0	0	0
2	1	1	1	1	1	1	1
3	2	0	2	0	2	0	2
4	3	0	0	3	0	0	3
5	U	U	U	U	U	U	U

Crop Harvest 2006 kg/ha

	N	Grain Yld	Straw Yld
	12	1449	1575
	12	4472	3755
	12	4806	4108
	12	5332	4646
	12	3796	3477
LSD ---		404	365

Crop Sample N & S Analysis % N and %S in tissue

Grain S	Straw S	Grain N	Straw N
0.2	0.3	1.6	0.7
0.3	0.3	1.6	0.6
0.2	0.3	1.5	0.6
0.3	0.3	1.7	0.9
0.3	0.3	1.6	0.6
0.0	0.1	0.1	0.2

Sulphur Application

		N	Grain Yld	Straw Yld
1	No Sulphur Added	20	3715	3357
2	Elemental S (Tiger 90)	20	3912	3673
3	Potassium Sulfate(K-SO4)	20	3946	3646
LSD ---			313	283

Grain S	Straw S	Grain N	Straw N
0.2	0.4	1.7	0.9
0.3	0.3	1.5	0.8
0.3	0.3	1.6	0.6
0.0	0.1	0.1	0.2

Rate of Manure X Sulfur Ammendment

		N	Grain Yld	Straw Yld
1	0 0 0 0 0 0 0	4	1472 350	1323 277
	1 No S	4	1527 205	1601 289
	2 Tiger 90	4	1349 276	1601 247
	3 SO4 S			
2	1 1 1 1 1 1 1	N		
	1 No S	4	4959 626	3959 334
	2 Tiger 90	4	4424 824	3636 783
	3 SO4 S	4	4033 1062	3640 702
3	2 0 2 0 2 0 2	N		
	1 No S	4	4628 498	4232 908
	2 Tiger 90	4	4951 156	4305 647
	3 SO4 S	4	4839 429	3786 516
4	3 0 0 3 0 0 3	N		
	1 No S	4	5253 203	4684 714
	2 Tiger 90	4	5647 315	4758 671
	3 SO4 S	4	5095 382	4496 510
5	U U U U U U U	N		
	1 No S	4	2261 1141	2557 921
	2 Tiger 90	4	4883 732	4068 170
	3 SO4 S	4	4244 582	3806 697

Grain S	Straw S	Grain N	Straw N
0.1 0.1	0.4 0.1	1.6 0.2	0.7 0.1
0.3 0.1	0.3 0.1	1.6 0.2	0.7 0.3
0.3 0.0	0.3 0.2	1.7 0.2	0.7 0.2
0.3 0.1	0.3 0.1	1.7 0.1	0.8 0.2
0.3 0.0	0.3 0.1	1.6 0.2	0.6 0.1
0.2 0.0	0.2 0.0	1.5 0.1	0.5 0.1
0.2 0.1	0.4 0.2	1.6 0.2	0.6 0.1
0.2 0.0	0.3 0.2	1.4 0.0	0.6 0.2
0.3 0.1	0.3 0.1	1.5 0.0	0.6 0.1
0.2 0.1	0.4 0.1	1.9 0.2	1.7 1.1
0.3 0.1	0.3 0.1	1.5 0.1	0.5 0.1
0.3 0.0	0.1 0.1	1.6 0.1	0.6 0.2
0.2 0.0	0.3 0.0	1.6 0.2	0.7 0.4
0.2 0.1	0.3 0.2	1.5 0.1	0.5 0.1
0.3 0.0	0.5 0.2	1.6 0.1	0.6 0.1

Soil Analysis (0-15 cm) (Elemental Sulfur Plots 0-30 cm) kg/ha

pH		E.C.		NO_3		NH_4		SO_4		P		K	
7.2	0.2	0.12	0.01	6.0	1.4	6.1	2.5	7.1	3.1	18.8	9.6	497.1	165.2
7.0	0.1	0.11	0.01	8.8	4.7	13.2	4.6	12.5	3.3	25.5	3.9	466.6	491.6
6.9	0.2	0.15	0.06	5.8	2.3	14.2	4.5	24.4	35.2	20.4	5.0	585.5	97.0
7.1	0.2	0.13	0.02	7.6	0.9	11.3	6.2	7.0	2.7	16.5	10.5	759.5	267.7
7.1	0.2	0.13	0.03	9.9	1.5	12.9	1.2	13.8	5.1	26.7	13.6	1311.2	216.5
6.9	0.1	0.13	0.02	8.9	1.4	7.8	3.2	7.6	1.6	17.7	6.4	602.0	158.3
7.1	0.2	0.13	0.02	5.9	1.1	8.4	1.5	6.5	1.3	15.7	5.7	674.0	191.9
7.0	0.1	0.12	0.02	15.4	7.7	17.3	7.0	11.1	3.8	27.4	9.7	1058.3	184.7
6.9	0.1	0.13	0.01	6.5	1.4	7.8	3.0	7.7	1.0	16.0	4.1	714.6	147.2
7.1	0.1	0.14	0.01	8.6	1.7	8.0	1.1	7.3	1.6	18.1	10.1	773.3	129.4
7.0	0.1	0.13	0.01	12.9	8.0	15.7	4.1	13.9	7.5	22.8	10.1	1015.4	193.9
6.9	0.2	0.13	0.02	7.0	2.9	9.2	1.6	8.2	3.0	16.6	9.3	626.6	108.2
7.0	0.2	0.13	0.03	13.7	13.2	8.2	1.9	5.3	0.4	15.2	6.6	523.6	175.1
7.0	0.1	0.10	0.02	11.7	6.4	17.8	1.1	13.4	4.3	19.8	5.9	846.5	33.0
6.8	0.1	0.12	0.01	9.2	1.0	10.6	3.8	6.1	1.1	14.6	4.7	522.3	12.5

Crop Harvest Fall 2006

Manure Rate - No Sulphur Ammendment

Trt	Rate 2000	2001	2002	2003	2004	2005	2006
1	0	0	0	0	0	0	0
2	1	1	1	1	1	1	1
3	2	0	2	0	2	0	2
4	3	0	0	3	0	0	3
5	U	U	U	U	U	U	U

	N	Grain Yld	Straw Yld
	4	1472 350	1323 277
	4	4958 626	3959 334
	4	4628 498	4232 908
	4	5253 203	4684 714
	4	2261 1141	2557 921
LSD ---		766	692

Crop Sample N & S Analysis

Grain S	Straw S	Grain N	Straw N
0.1 0.1	0.4 0.1	1.6 0.2	0.7 0.1
0.3 0.1	0.3 0.2	1.7 0.1	0.6 0.2
0.2 0.1	0.4 0.2	1.6 0.2	0.6 0.1
0.2 0.1	0.4 0.1	1.9 0.2	1.7 1.1
0.2 0.0	0.3 0.0	1.6 0.2	0.7 0.4
0.1	0.2	0.3	0.7

Soil Analysis (0-15 cm) (Elemental Sulfer Plots 0-30 cm)

pH		E.C.		NO_3		NH_4		SO_4		P		K	
7.2	0.2	0.12	0.01	6.0	1.4	6.1	2.5	7.1	3.1	18.8	9.6	497.1	165.2
7.1	0.2	0.13	0.02	7.6	0.9	11.3	6.2	7.0	2.7	16.5	10.5	759.5	267.7
7.1	0.2	0.13	0.02	5.9	1.1	8.4	1.5	6.5	1.3	15.7	5.7	674.0	191.9
7.1	0.1	0.14	0.01	8.6	1.7	8.0	1.1	7.3	1.6	18.1	10.1	773.3	129.4
7.0	0.2	0.13	0.03	13.7	13.2	8.2	1.9	5.3	0.4	15.2	6.6	523.6	175.1
0.1		0.03		7.6		4.2		2.0		5.4		167.7	

Manure Rate - Elemental Sulphur T 90 Ammendment

Trt	Rate 2000	2001	2002	2003	2004	2005	2006
1	0	0	0	0	0	0	0
2	1	1	1	1	1	1	1
3	2	0	2	0	2	0	2
4	3	0	0	3	0	0	3
5	U	U	U	U	U	U	U

	N	Grain Yld	Straw Yld
	4	1527 205	1601 289
	4	4424 824	3636 783
	4	4951 156	4305 647
	4	5647 315	4758 671
	4	4883 732	4068 170
LSD ---		659	605

Grain S	Straw S	Grain N	Straw N
0.3 0.1	0.3 0.1	1.6 0.2	0.7 0.3
0.3 0.0	0.3 0.1	1.5 0.2	0.6 0.1
0.2 0.0	0.3 0.2	1.4 0.0	0.6 0.2
0.3 0.1	0.3 0.1	1.5 0.1	0.5 0.1
0.2 0.1	0.3 0.2	1.5 0.1	0.5 0.1
0.0	0.2	0.2	0.2

pH		E.C.		NO_3		NH_4		SO_4		P		K	
7.0	0.1	0.11	0.01	8.8	4.7	13.2	4.6	12.5	3.3	25.5	3.9	466.6	491.6
7.1	0.2	0.13	0.03	9.9	1.5	12.9	1.2	13.8	5.1	26.7	13.6	1311.2	216.5
7.0	0.1	0.12	0.02	15.4	7.7	17.3	7.0	11.1	3.8	27.4	9.7	1058.3	184.7
7.0	0.1	0.13	0.01	12.9	8.0	15.7	4.1	13.9	7.5	22.8	10.1	1015.4	193.9
7.0	0.1	0.10	0.02	11.7	6.4	17.8	1.1	13.4	4.3	19.8	5.9	846.5	33.0
0.1		0.02		1.6		5.2		4.5		7.6		316.5	

Manure Rate - Potassium Sulphate Ammendment

Trt	Rate 2000	2001	2002	2003	2004	2005	2006
1	0	0	0	0	0	0	0
2	1	1	1	1	1	1	1
3	2	0	2	0	2	0	2
4	3	0	0	3	0	0	3
5	U	U	U	U	U	U	U

	N	Grain Yld	Straw Yld
	4	1349 276	1601 247
	4	4033 1062	3640 702
	4	4839 429	3786 516
	4	5095 382	4496 510
	4	4244 582	3806 697
LSD ---		767	700

Grain S	Straw S	Grain N	Straw N
0.3 0.0	0.3 0.2	1.7 0.2	0.7 0.2
0.2 0.0	0.2 0.0	1.5 0.1	0.5 0.1
0.3 0.1	0.3 0.1	1.5 0.0	0.6 0.1
0.3 0.0	0.1 0.1	1.6 0.1	0.6 0.2
0.1 0.0	0.3 0.2	1.6 0.1	0.6 0.1
0.1	0.2	0.1	0.2

pH		E.C.		NO_3		NH_4		SO_4		P		K	
6.9	0.2	0.15	0.06	5.8	2.3	14.2	4.5	24.4	35.2	20.4	5.0	585.5	97.0
6.9	0.1	0.13	0.02	8.9	1.4	7.8	3.2	7.6	1.6	17.7	6.4	602.0	158.3
6.9	0.1	0.13	0.01	6.5	1.4	7.8	3.0	7.7	1.0	16.0	4.1	714.6	147.2
6.9	0.2	0.13	0.02	7.0	2.9	9.2	1.6	8.2	3.0	16.6	9.3	626.6	108.2
6.8	0.1	0.12	0.01	9.2	1.0	10.6	3.8	6.1	1.1	14.6	4.7	522.3	12.5
0.1		0.04		2.1		4.5		19.4		7.2		151.2	

Note: 1. Crop harvest (grain and straw yields) means in kg/ha
2. Elemental sulfer (Tiger 90) plots sampled at: 0-30 cm, 30-60 cm and 60-120 cm depths
3. No S and potassium sulfate plots sampled at: 0-15 cm, 15-30 cm, 30-60 cm and 60-120 cm depths
4. Grain and Straw N and S means in per cent (%)
5. Soil Extractable NH_4, NO_3, SO_4, P & K means in kg/ha
6. Electrical conductivity means in mS/cm
7. Means in the first column are followed by standard deviations in the second column
8. N=Number of observations
9. LSD (or MD) calculated at 0.5 (5%)

Soil Analysis (15-30 cm) (No S & K_2SO_4 Plots) kg/ha

pH		E.C		NO_3		NH_4		SO_4		P		K	
7.3	0.1	0.11	0.02	2.2	0.3	7.5	3.9	9.2	9.3	6.4	4.3	254.3	35.4
7.6	0.1	0.01	0.01	1.1	0.5	8.9	2.5	4.8	0.7	7.6	1.3	308.6	50.5
7.2	0.1	0.10	0.01	3.5	2.2	8.9	4.2	3.5	1.4	7.5	3.8	308.7	35.4
7.1	0.1	0.11	0.01	3.4	0.3	9.7	4.4	5.5	1.4	6.2	0.5	332.0	48.1
7.3	0.1	0.10	0.01	2.2	0.4	9.2	3.2	3.1	0.7	7.2	3.3	281.0	32.3
7.1	0.1	0.10	0.01	3.0	0.2	11.7	2.1	4.2	1.3	7.6	2.2	321.4	28.5
7.3	0.2	0.11	0.02	4.6	1.6	7.4	2.0	3.5	1.5	6.5	3.6	351.2	91.1
7.2	0.1	0.12	0.02	4.6	2.5	5.9	3.2	9.1	10.2	6.7	0.9	279.5	67.2
7.2	0.1	0.11	0.01	4.6	4.3	6.7	3.0	2.6	0.5	6.6	3.4	347.5	45.6
7.0	0.1	0.10	0.01	3.5	0.2	8.5	2.8	3.5	0.5	6.7	1.3	327.4	34.1

Soil Analysis (15-30 cm) (No S & K_2SO_4 Plots)

pH		E.C		NO_3		NH_4		SO_4		P		K	
7.3	0.1	0.11	0.02	2.2	0.3	7.5	3.9	9.2	9.3	6.4	4.3	254.3	35.4
7.2	0.1	0.10	0.01	3.5	2.2	8.9	4.2	3.5	1.4	7.5	3.8	308.7	35.4
7.3	0.1	0.10	0.01	2.2	0.4	9.2	3.2	3.1	0.7	7.2	3.3	281.0	32.3
7.3	0.2	0.11	0.02	4.6	1.6	7.4	2.0	3.5	1.5	6.5	3.6	351.2	91.1
7.2	0.1	0.11	0.01	4.6	4.3	6.7	3.0	2.6	0.5	6.6	3.4	347.5	45.6
	0.1		0.02		1.1		3.0		5.1		4.6		72.2
7.0	0.1	0.11	0.01	3.1	0.5	8.9	2.5	4.8	0.7	7.6	1.3	308.6	50.5
7.1	0.1	0.11	0.01	3.4	0.3	9.7	4.4	5.5	1.4	6.2	0.5	332.0	48.1
7.1	0.1	0.10	0.01	3.0	0.2	7.7	2.1	4.2	1.3	7.6	2.2	321.4	28.5
7.2	0.1	0.12	0.02	4.6	2.5	5.9	3.2	9.1	10.2	6.7	0.9	279.5	67.2
7.6	0.1	0.10	0.01	3.5	0.2	8.5	2.8	3.5	0.5	6.7	1.3	327.4	34.1
	0.1		0.02		1.4		3.5		5.6		1.6		54.6

Soil Analysis (30-60 cm) kg/ha

NO_3		NH_4		SO_4	
3.4	0.2	12.2	5.9	6.8	1.4
3.3	0.4	11.2	3.7	5.1	4.4
4.4	0.7	17.8	3.6	21.0	21.4
3.7	0.8	14.3	9.2	5.9	1.1
3.7	0.1	20.1	11.4	7.2	4.4
5.1	0.8	21.2	4.1	30.5	35.6
4.0	0.7	13.7	4.5	4.8	3.3
5.0	1.5	14.0	3.5	4.9	3.2
5.1	1.1	20.0	5.0	9.8	4.6
7.9	2.5	13.3	1.5	7.0	3.0
8.9	9.5	15.2	1.8	6.2	5.6
7.3	3.3	22.1	5.1	9.4	2.7
5.0	2.3	17.0	10.8	30.2	50.4
3.7	1.3	17.0	2.5	2.8	2.2
4.9	0.7	19.2	6.8	7.2	1.2

Soil Analysis (30-60 cm)

NO_3		NH_4		SO_4	
3.4	0.2	12.2	5.9	6.8	1.4
3.7	0.8	14.3	9.2	5.9	1.1
4.0	0.7	13.7	4.5	4.8	3.3
7.9	2.5	13.3	1.5	7.0	3.0
5.0	2.3	17.0	10.8	30.2	50.4
	1.7		7.6		28.7
3.3	0.4	11.2	3.7	5.1	4.4
3.7	0.1	20.1	11.4	7.2	4.4
5.0	1.5	14.0	3.5	4.9	3.2
8.9	9.5	15.2	1.8	6.2	5.6
3.7	1.3	17.0	2.5	2.8	2.2
	5.1		6.2		4.4
4.4	0.7	17.8	3.6	21.0	21.4
5.1	0.8	21.2	4.1	30.5	35.6
5.1	1.1	20.0	5.0	9.8	4.6
7.3	3.3	22.1	5.1	9.4	2.7
4.9	0.7	19.2	6.8	7.2	1.2
	1.9		5.9		24.0

Soil Analysis (60-120 cm) kg/ha

NO_3		NH_4		SO_4	
5.7	0.8	30.2	13.6	29.7	43.7
11.6	2.3	50.6	32.0	203.8	301.6
8.0	1.1	23.6	9.5	21.3	24.5
13.0	2.1	32.0	12.1	33.0	11.9
8.8	2.1	32.4	21.7	12.1	15.0
12.0	1.5	37.6	5.4	30.2	15.5
13.8	4.9	22.8	9.9	11.1	6.3
16.0	7.0	34.4	3.6	30.5	4.5
12.0	4.2	33.0	26.2	11.9	5.0
11.0	1.2	47.8	19.0	28.0	5.4

Soil Analysis (60-120 cm)

NO_3		NH_4		SO_4	
5.7	0.8	30.2	13.6	29.7	43.7
8.0	1.1	23.6	9.5	21.3	24.5
8.8	2.1	32.4	21.7	12.1	15.0
13.8	4.9	22.8	9.9	11.1	6.3
12.0	4.2	33.0	26.2	11.9	5.0
	4.1		18.8		21.5
11.6	2.3	50.6	32.0	203.8	301.6
13.0	2.1	32.0	12.1	33.0	11.9
12.0	1.5	37.6	5.4	30.2	15.5
16.0	7.0	34.4	3.6	30.5	4.5
11.0	1.2	47.8	19.0	28.0	5.4
	4.8		24.2		170.8

TABLE 4B. Plenty Swine Manure Site 2006 Yield, Crop and Soil Nutrients

2006 Canola Crop Harvest

Regime	1999	2000	2001	2002	2003	2004	2005	2006	N	Crop Harvest 2006 kg/ha Grain Yld.	Crop Harvest 2006 kg/ha Straw Yld.	Grain N & P mg/g Total N	Grain N & P mg/g Total P	Straw N & P mg/g Total N	Straw N & P mg/g Total P
1	X	O	O	O	O	O	O	O	15						
2	X	O	O	X	O	O	X	O	15						
3	X	O	X	O	X	O	X	O	15	3838	2636	33 6	4 8	5 3	0 4
4	X	X	O	O	X	X	O	O	15	3907	2715	33 1	4 8	5 1	0 4
5	X	X	X	O	O	X	O	O	15	3855	2643	35 2	4 7	5 3	0 4
6	X	X	X	X	X	X	X	X	15	4753	3283	38 1	4 8	6 7	0 6
									LSD	398	285	1 7	0 3	0 7	0 1

Source		N	Grain Yld.	Straw Yld.	Total N	Total P	Total N	Total P
1	Check	12	1631	1158	30 0	5 1	5 1	0 5
2	Low Hog Manure 37 000 L ha^{-1}	12	6048	4142	39 5	5 0	6 5	0 4
3	High Hog Manure 74 000 L ha^{-1}	12	5938	4019	39 5	5 5	7 6	0 6
4	Low Fertilizer 40 kg N ha^{-1}	12	3068	2190	30 6	4 4	4 0	0 3
5	High Fertilizer 80 kg N ha^{-1}	12	3758	2587	35 3	3 9	4 7	0 3
		LSD	445	319	1 9	0 3	0 8	0 1

	1999	2000	2001	2002	2003	2004	2005	2006	N	Crop Harvest Fall 2006 Grain Yld.		Crop Harvest Fall 2006 Straw Yld.		Grain N & P Analysis Total N		Grain N & P Analysis Total P		Straw N & P Analysis Total N		Straw N & P Analysis Total P	
3	X	O	X	O	X	O	X	O	N												
	1 Check								3	1587	814	1137	539 9	31 4	4 0	5 3	0 2	5 5	0 4	0 6	0 1
	2 Low Hog Manure 37 000 L ha^{-1}								3	5553	439	3914	249	38 2	1 0	4 8	0 3	6 0	0 8	0 4	0 0
	3 High Hog Manure 74 000 L ha^{-1}								3	5707	598	3727	329	38 7	1 0	5 4	0 5	6 7	0 3	0 6	0 1
	4 Low Fertilizer 40 kg N ha^{-1}								3	2647	1123	1971	916	28 2	0 3	4 5	0 8	3 8	0 2	0 3	0 0
	5 High Fertilizer 80 kg N ha^{-1}								3	3597	222	2431	189	31 4	3 9	3 9	0 5	4 4	0 6	0 4	0 1
									LSD	657		530		4 2		0 6		0 8		0 1	
8	1999	2000	2001	2002	2003	2004	2005	2006	N												
	X	X	O	O	X	X	O	O													
	1 Check								3	1510	302	1064	198	27 6	1 1	5 0	0 3	4 2	0 2	0 4	0 1
	2 Low Hog Manure 37 000 L ha^{-1}								3	5847	706	3948	489	39 0	0 8	4 8	0 3	5 8	0 6	0 3	0 0
	3 High Hog Manure 74 000 L ha^{-1}								3	6753	101	4605	185	39 0	0 9	5 5	0 2	7 0	0 8	0 5	0 1
	4 Low Fertilizer 40 kg N ha^{-1}								3	2280	918	1722	649	27 0	1 4	4 6	0 3	4 2	0 8	0 4	0 1
	5 High Fertilizer 80 kg N ha^{-1}								3	3147	669	2236	419	33 0	4 4	4 0	0 8	4 3	0 9	0 3	0 1
									LSD	968		718		3 0		0 5		1 1		0 2	
5	1999	2000	2001	2002	2003	2004	2005	2006	N												
	X	X	X	O	O	X	O	O													
	1 Check								3	2063	382	1488	286	29 2	0 6	4 8	0 3	4 7	0 9	0 4	0 1
	2 Low Hog Manure 37 000 L ha^{-1}								3	6013	689	4137	462	39 1	0 2	4 9	0 3	6 6	0 9	0 4	0 0
	3 High Hog Manure 74 000 L ha^{-1}								3	5133	903	3446	539	39 1	0 8	5 5	0 5	6 6	1 2	0 4	0 1
	4 Low Fertilizer 40 kg N ha^{-1}								3	2417	382	1641	222	30 4	4 5	4 4	0 8	3 9	0 9	0 3	0 1
	5 High Fertilizer 80 kg N ha^{-1}								3	3650	598	2503	408	38 1	1 4	3 9	0 5	4 9	0 5	0 3	0 1
									LSD	985		640		3 5		0 8		1 1		0 1	
6	1999	2000	2001	2002	2003	2004	2005	2006	N												
	X	X	X	X	X	X	X	X													
	1 Check								3	1363	743	842	682	31 8	7 0	5 2	0 5	6 2	3 4	0 7	0 3
	2 Low Hog Manure 37 000 L ha^{-1}								3	6677	550	4571	320	41 8	1 6	5 4	0 3	7 8	1 3	0 6	0 2
	3 High Hog Manure 74 000 L ha^{-1}								3	6160	1168	4296	875	41 3	0 3	5 5	0 2	10 1	0 8	1 0	0 1
	4 Low Fertilizer 40 kg N ha^{-1}								3	4927	679	3428	533	39 8	1 3	4 1	0 6	4 0	0 6	0 3	0 0
	5 High Fertilizer 80 kg N ha^{-1}								3	4637	1475	3178	1009	38 5	0 3	3 6	0 3	5 3	1 4	0 3	0 1
									LSD	1214		869		5 4		0 5		3 0		0 3	

Soil Analysis (0-15 cm) Regime 3 (0-30 cm)													
pH		E.C.		NO$_3$		NH$_4$		P		K	
8 2	0 1	0 27	0 06	13 5	7 4	15 2	10 7	21 0	1 5	1899 6	297 6
8 1	0 0	0 30	0 04	29 2	20 2	9 8	8 4	24 9	3 6	2336 9	313 1
8 1	0 1	0 28	0 02	11 7	1 9	7 5	6 3	30 3	6 1	2089 5	361 0
8 2	0 0	0 28	0 01	18 8	13 9	16 3	16 1	21 7	1 9	1900 3	376 4
8 0	0 3	0 25	0 03	25 6	26 4	12 0	6 2	21 8	3 0	2184 9	67 1
0 2		0 05		27 8		7 0		5 7		488 5	
8 1	0 0	0 29	0 05	23 4	12 9	7 0	2 8	12 2	4 5	1208 5	125 8
8 0	0 1	0 32	0 06	25 0	17 7	9 0	1 8	22 7	18 9	1048 8	544 9
8 0	0 1	0 33	0 08	19 9	12 7	5 5	6 3	54 5	19 5	1553 5	201 7
8 1	0 1	0 35	0 16	16 4	20 5	4 5	4 0	10 1	1 3	892 7	105 8
8 1	0 0	0 28	0 02	22 5	23 8	7 2	4 6	12 3	3 7	934 7	405 7
0 1		0 15		30 2		3 6		19 1		542 9	

Note 1. Crop harvest (grain and straw yields) means in kg ha^{-1}

2. Crop damage to Regimes 1 & 2 due to cotyledon spraying error, therefore no crop samples

3. Grain and Straw Total N and Total P means in mg g^{-1}

4. Soil Extractable NH4, NO3, P & K means in kg ha^{-1}

5. Electrical conductivity means in mS cm^{-1}

6. Means in the first column are followed by standard deviations in the second column

7. For Fall 2006, only Regimes 3 and 6 were soil sampled

8. Regime 3 was sampled at 0-30, 30-60 (NO3 & NH4 only) and 60-120 cm (NO3 & NH4 only)

9. Regime 6 was sampled at 0-15, 15-30, 30-60 (NO3 & NH4 only) and 60-120 cm (NO3 & NH4 only)

10. N=Number of observations

11. LSD (0.10) calculated at p ≤ 0.10

Soil Analysis (15-30 cm)												Soil Analysis (30-60 cm)				Soil Analysis (60-120 cm)			
pH		E.C.		NO_3		NH_4		P		K		NO_3		NH_4		NO_3		NH_4	
												8.8	2.6	13.7	10.5	14.7	2.4	50.1	33.1
												13.1	6.7	7.3	10.1	48.0	18.1	38.9	17.0
												28.1	24.2	7.2	7.4	626.7	225.5	50.9	19.0
												7.9	0.8	16.8	18.7	16.5	5.8	84.1	90.7
												8.8	1.1	4.3	2.7	13.9	1.2	33.6	15.9
												18.0		10.4		155.0		60.6	
8.2	0.1	0.29	0.02	6.7	1.0	6.8	3.1	16.1	8.1	523.4	19.0	8.4	0.4	37.6	40.2	17.9	9.5	57.3	15.9
8.3	0.0	0.26	0.01	6.3	2.2	7.4	2.6	12.8	4.7	443.1	91.9	64.4	33.9	20.7	7.6	741.3	189.4	90.9	53.0
8.3	0.1	0.28	0.03	9.6	3.1	5.4	5.1	12.4	3.2	898.4	715.6	330.7	102.8	20.6	27.6	1093.3	166.5	72.3	41.9
8.3	0.0	0.26	0.02	4.1	0.2	4.7	4.3	32.7	37.5	538.5	99.2	7.5	1.2	21.2	13.9	14.4	0.8	120.5	47.7
8.3	0.1	0.27	0.02	5.5	0.7	5.5	4.6	10.3	3.1	661.9	309.8	15.9	4.4	18.9	17.0	83.5	39.8	80.5	67.5
8.1		0.04		2.9		3.4		25.5		506.5		73.6		24.4		178.1		51.3	

TABLE 5B. Riverhurst Swine Manure Site 2006 Yield, Crop, Soil Nutrients

2006 Oat Green Feed Crop Harvest

Regime

	1999	2000	2001	2002	2003	2004	2005	2006	N	Crop Harvest Fall 2006 Total Biomass	Biomass N & P Analysis Total N	Total P
1	X	O	O	O	O	O	O	O	15	7262	73	22
2	X	O	O	X	O	O	X	O	15	9304	100	23
3	X	O	X	O	X	O	X	O	15	8879	90	20
4	X	X	O	O	X	X	O	O	15	8427	84	21
5	X	X	X	O	O	X	O	O	15	8535	84	21
6	X	X	X	X	X	X	X	X	15	8406	91	23
									LSD ...	901	09	01

Source

		N	Total Biomass	Total N	Total P
1	Check	18	7516	74	20
2	Low Hog Manure 37 000 L ha	18	9403	98	23
3	High Hog Manure 74 000 L ha	18	9442	110	23
4	Low Fertilizer 40 kg N ha	18	8036	79	20
5	High Fertilizer 80 kg N ha	18	7942	81	20
	LSD ...		822	08	01

Effect of Source within Regime

1

1999	2000	2001	2002	2003	2004	2005	2006
X	O	O	O	O	O	O	O

	N	Total Biomass		Total N		Total P	
1 Check	3	6297	281	71	04	19	01
2 Low Hog Manure 37 000 L ha	3	7383	729	79	04	22	01
3 High Hog Manure 74 000 L ha	3	7960	629	89	10	27	03
4 Low Fertilizer 40 kg N ha	3	7880	1279	75	11	19	05
5 High Fertilizer 80 kg N ha	3	7090	520	71	05	22	02
LSD ...			701		11		02

2

1999	2000	2001	2002	2003	2004	2005	2006
X	O	O	X	O	O	X	O

	N	Total Biomass		Total N		Total P		Soil Analysis (0-15 cm) (Regimes 2 and 3: 0-30 cm) pH		E.C.		NO3		NH4		P		K		Soil Analysis (15-30 c pH	E.C	NO3
1 Check	3	7627	533	94	18	22	01	78	03	015	004	76	00	29	28	126	21	483 7	994			
2 Low Hog Manure 37 000 L ha	3	9303	818	112	30	24	04	78	03	016	003	97	33	11	15	193	67	561 1	1499			
3 High Hog Manure 74 000 L ha	3	9797	316	111	20	20	03	79	03	016	006	128	07	63	40	259	79	518 8	532			
4 Low Fertilizer 40 kg N ha	3	10290	913	103	19	21	03	79	03	019	005	83	18	32	49	129	16	451 1	1415			
5 High Fertilizer 80 kg N ha	3	9303	1298	106	19	20	02	78	03	018	003	113	44	80	37	133	19	565 6	85 6			
LSD ...			1441		36		04		05		007		39		59		62		1596			

3

1999	2000	2001	2002	2003	2004	2005	2006
X	O	X	O	X	O	X	O

	N	Crop Harvest Fall 2006 Total Biomass		Biomass N & P Analysis Total N		Total P		Soil Analysis (0-15 cm) (Regimes 2 and 3: 0-30 cm) pH		E.C.		NO3		NH4		P		K		Soil Analysis (15-30 c pH	E.C	NO3
1 Check	3	7877	1193	70	06	17	01	80	02	018	003	65	09	61	21	123	25	269 3	223			
2 Low Hog Manure 37 000 L ha	3	10520	502	95	07	19	00	78	02	015	002	80	14	56	14	144	11	323 7	842			
3 High Hog Manure 74 000 L ha	3	9573	1727	123	15	22	02	81	03	021	004	92	29	69	19	217	132	274 5	635			
4 Low Fertilizer 40 kg N ha	3	7477	1046	77	17	20	02	77	02	014	002	156	142	71	20	128	17	333 1	423			
5 High Fertilizer 80 kg N ha	3	8947	1335	87	11	21	03	80	02	019	004	80	16	80	16	123	07	306 7	159			
LSD ...			2042		18		03		04		005		107		24		98		839			

4

1999	2000	2001	2002	2003	2004	2005	2006
X	X	O	O	X	X	O	O

	N	Crop Harvest Fall 2006 Total Biomass		Biomass N & P Analysis Total N		Total P	
1 Check	3	8417	3478	70	18	20	01
2 Low Hog Manure 37 000 L ha	3	9313	2266	89	18	25	05
3 High Hog Manure 74 000 L ha	3	10053	962	119	05	21	01
4 Low Fertilizer 40 kg N ha	3	7550	1784	68	12	19	03
5 High Fertilizer 80 kg N ha	3	6803	1574	73	04	20	03
LSD ...			3674		18		05

5

1999	2000	2001	2002	2003	2004	2005	2006
X	X	X	O	O	X	O	O

	N	Crop Harvest Fall 2006 Total Biomass		Biomass N & P Analysis Total N		Total P	
1 Check	3	8437	1035	85	01	20	00
2 Low Hog Manure 37 000 L ha	3	9450	1269	92	24	23	02
3 High Hog Manure 74 000 L ha	3	10153	1435	107	37	24	04
4 Low Fertilizer 40 kg N ha	3	8377	1256	82	17	20	02
5 High Fertilizer 80 kg N ha	3	7867	2852	72	16	17	02
LSD ...			2734		27		04

6

1999	2000	2001	2002	2003	2004	2005	2006
X	X	X	X	X	X	X	X

	N	Crop Harvest Fall 2006 Total Biomass		Biomass N & P Analysis Total N		Total P		Soil Analysis (0-15 cm) (Regimes 2 and 3: 0-30 cm) pH		E.C.		NO3		NH4		P		K		Soil Analysis (15-30 c pH	E.C	NO3
1 Check	3	7840	493	76	05	24	04	77	01	013	001	39	03	50	33	145	77	197 2	414	80	03	02	00	64	07
2 Low Hog Manure 37 000 L ha	3	10447	1627	120	08	22	02	76	01	021	006	67	01	63	41	263	45	219 5	647	82	00	02	00	76	04
3 High Hog Manure 74 000 L ha	3	9417	1260	110	13	24	01	73	04	018	002	119	62	58	22	437	126	218 7	1063	82	01	02	00	91	12
4 Low Fertilizer 40 kg N ha	3	6643	530	70	07	21	02	78	03	018	003	53	20	57	17	108	43	157 7	673	80	03	02	00	67	05
5 High Fertilizer 80 kg N ha	3	7653	234	78	17	22	02	76	01	013	002	53	23	39	04	125	65	172 6	446	81	00	02	00	76	14
LSD ...			1490		18		03		03		004		43		42		81		566		03		00		16

Note 1. Crop harvest (total biomass (grain + straw) yields) means in kg ha
2. Crop harvested at green stage (cooperator harvesting at green stage to feed cattle), therefore total biomass only
3. Total Biomass (Grain + Straw), total N and total P means in us ti
4. Soil Extractable NH4, NO3, P & K means in kg ha
5. Electrical conductivity means in mS cm
6. Means in the first column are followed by standard deviations in the second column
7. For Fall 2006, only Regimes 2, 3 and 6 were soil sampled
8. Regimes 2 and 3 were sampled at 0-30 and 30-60 (NO3 & NH4 only)
9. Regime 6 was sampled at 0-15, 15-30 and 30-60 (NO3 & NH4 only)
10. N=Number of observations
11. LSD (0.10) calculated at p ≤ 0.10

m) (Regime 6 Only)			Soil Analysis (30-60 cm)	
NH_4	P	K	NO_3	NH_4
			6.1 0.2	3.6 3.3
			10.3 5.7	4.0 4.4
			9.2 1.4	6.7 6.1
			8.4 1.1	2.8 3.6
			6.0 0.4	6.4 4.5
			4.3	5.8

m) (Regime 6 Only)			Soil Analysis (30-60 cm)	
NH_4	P	K	NO_3	NH_4
			6.4 0.4	5.8 2.2
			8.9 3.7	8.1 1.2
			84.8 111.0	7.7 0.2
			8.9 5.8	7.9 2.8
			6.3 0.2	8.7 2.7
			7.4.9	3.2

7.4	4.9	4.7	0.1	80.2	10.2	3.2	0.2	3.4	1.6
7.1	1.3	5.4	0.1	76.3	9.4	10.7	11.5	3.4	1.6
8.7	2.7	5.2	0.2	98.5	45.9	13.4	12.8	3.7	1.1
10.9	5.0	5.0	0.4	77.5	1.0	3.2	0.2	4.9	2.1
8.5	4.2	5.1	0.7	81.5	2.2	3.4	0.2	3.9	1.7
5.8		0.5		34.6		10.0		2.7	

Effect of Nitrification Inhibitor on Early Season Nitrogen Dynamics in 2005 and 2006 Field Seasons (Dixon only)

This section will deal with highlights, as a more detailed coverage of the effects of the nitrification inhibitor addition to liquid swine manure at the Dixon site is provided in the attached publication "Use of a Nitification Inhibitor to Improve Crop Recovery of Manure Nutrients" in the appendix.

The supply rates of ammonium and nitrate measured in the field using PRS probes, particularly in the 2005 field season, indicated that the nitrification inhibitor was effective in inhibiting nitrification and keeping more of the inorganic nitrogen in the ammonium form (Figure 14) and less in the nitrate form.

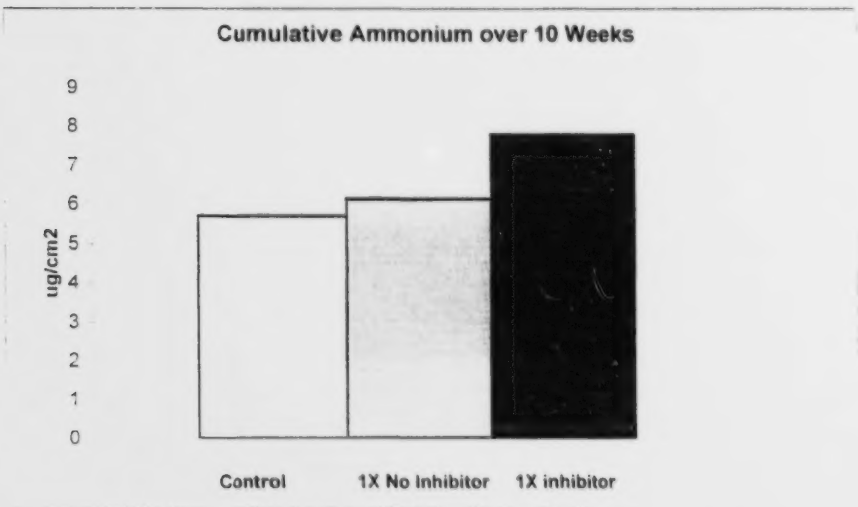


Figure 14. Cumulative ammonium supply rates (sum 10 weeks) measured over 2 week intervals at Dixon SK in June and July of 2005 using PRS cation and anion exchange membrane probes.

There were no significant differences in the biomass production over the growing season between the inhibitor treatments until the last sampling period, in which slightly higher biomass production was observed in the 1X (3300 gpa) treatment with inhibitor. The inhibitor treatment in 2005 resulted in significantly higher early season N uptake by the biomass only on the July 25th sampling period.

In the 2006 field season, the effects of the nitrification inhibitor treatment were diminished compared to the 2005 field season. The inhibitor had no significant effects on supply rates or concentrations of soil ammonium in the early season of 2006. This may be due to the fact that the inhibitor was added to manure that was applied in October of 2005. The longer delay between application of the inhibitor (fall) and measurement in the soil (late spring) would be anticipated to result in greater dissipation of the inhibitor and reduced effect. There was a trend towards slightly greater biomass yield and % N

recovery in the inhibitor treatment later on in the season. but the effects were not significant (Figure 15 and 16).

Biweekly Plant Samples (g 100cm^{-2}) Dixon 2006

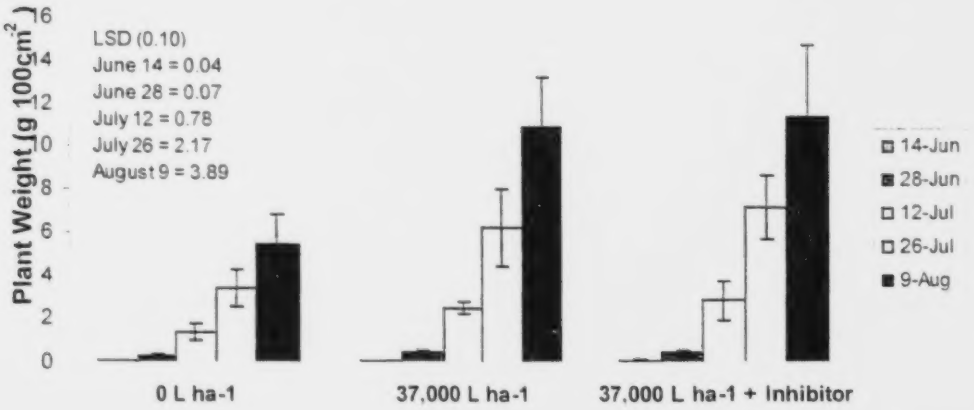


Figure 15. Flax biomass dry plant weight for three swine manure treatments over five two week periods at Dixon field site 2006.
* Inhibitor = 0.275 ml kg^{-1} of Super N Concentrate added to swine manure before application in fall of 2005.

Percent Nitrogen Recovery (Biweekly Samples) Dixon 2006

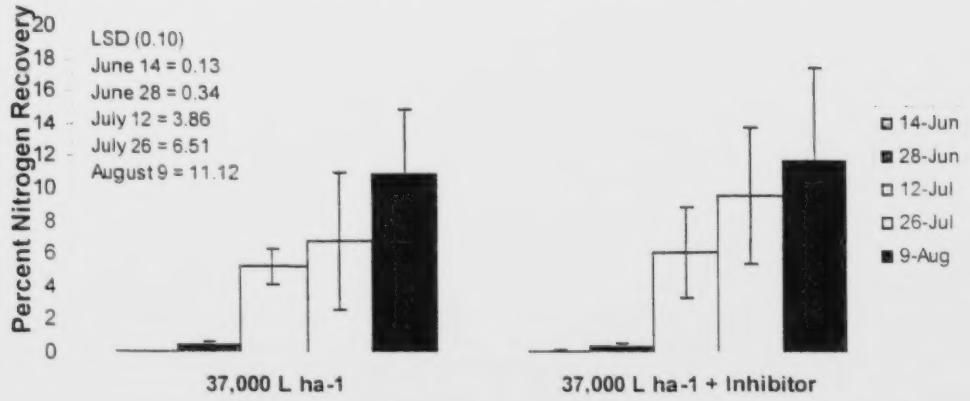


Figure 16. Percent nitrogen recovery in flax biomass for two swine manure treatments over five two week periods in the spring at Dixon field site 2006.
* Inhibitor = 0.275 ml kg^{-1} of Super N Concentrate added to swine manure before application.

Overall, it appears that while the inhibitor is effective in keeping more of the manure nitrogen in the ammonium form, especially when spring applied, the net effect on crop yield and N recovery is minimal. This may reflect lower loss potential for inorganic N accumulating as nitrate in Saskatchewan soils compared to other parts of the world such as the mid-western United States cornbelt where loss potential is much higher due to greater precipitation and where nitrification inhibitors are sometimes used.

Controlled Environment Leaching Study Using Soil Cores Collected from Dixon Swine and Cattle Manure Treatments

Addition of swine manure or cattle manure at agronomic rates (1X) did not significantly elevate the amount of organic and inorganic phosphorus contained in the leachate after 10 cm of simulated rainfall was passed through the cores. This agrees with the soil extractable P in the 1X swine manure treatment not being significantly elevated over the control (Table 1A), whereas the 4X swine manure treatment had nearly double the extractable P (54 vs 27 kg Modified Kelowna or MK extractable P / ha 0-15 cm). The cattle manure 1X treatment also had double the control (62 kg MK extractable P / ha 0-15cm in Table 2B) but leaching was not significantly increased over the control. Therefore, extractable soil test P may not always be a reliable indicator of relative leaching potential when different forms of manure are being compared. The soil test extraction only measures inorganic P, and it may be that the organic P added in swine manure is relatively more mobile in the soil profile than the organic P in cattle manure. In the cattle manure 4X treatment, which showed the greatest leaching in the cores, MK extractable P was elevated to ~ 180 kg MK extractable P / ha 0-15cm. As well, in the 15-30 cm depth the extractable P was doubled to 44 kg / ha compared to ~ 20 kg/ha in the control and 1X treatment, suggesting that some P leaching below 15 cm has taken place in the field with the 4X rate of cattle manure. It may be concluded that high annual application rates of cattle manure that supply the same amount of nitrogen as swine manure pose additional risk from P migration due to the build-up and potential movement of organic and inorganic P in the soil, although swine manure P may be more mobile per unit of P added.

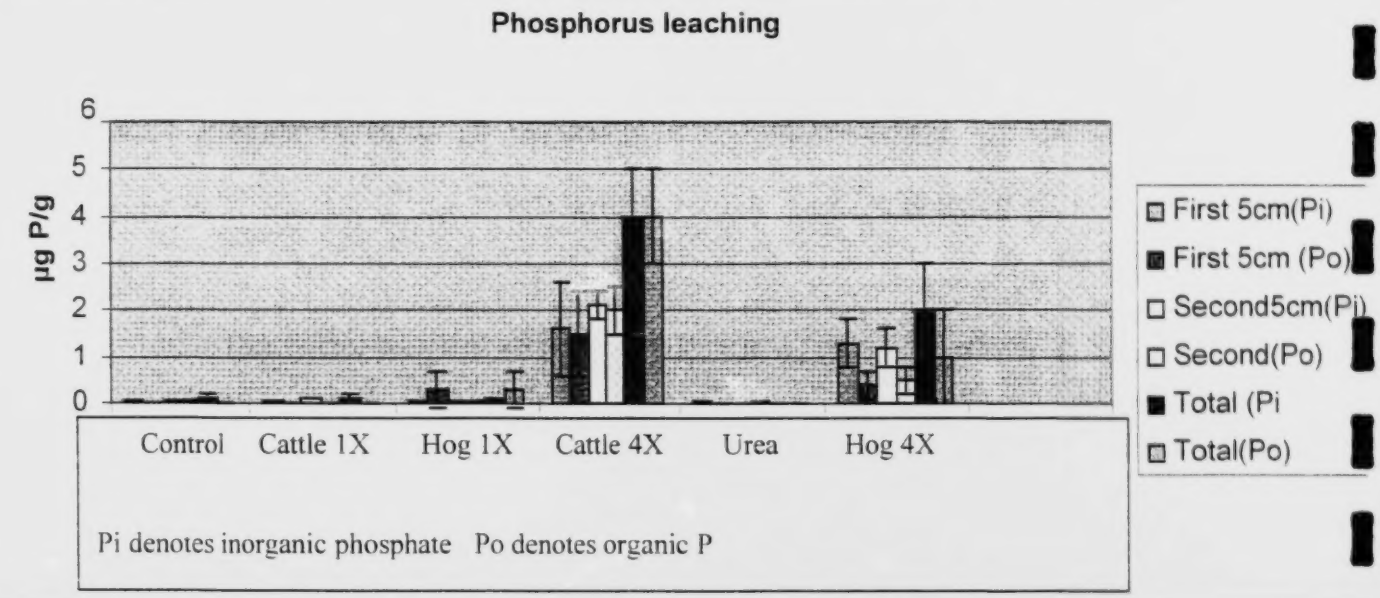


Figure 17. Phosphorus amounts and forms in leachate from soil cores sampled from Dixon swine and cattle manure treatments in fall of 2004 and that had two 5cm additions of simulated rainfall passed through in the laboratory.

The effect of manure treatment at Dixon site on the leaching of nitrate nitrogen is shown in Figure 18. The 1X cattle manure treatment (1X ~ 100 kg N/ha/yr) showed nitrate leaching through the core that was not significantly different than the control while the 1X annual rate of swine manure (1X ~ 100 kg N/ha/yr) was only slightly elevated. Urea applied at 100 kg N/ ha/ yr was similar to the swine manure. These results agree with the findings that the soil nitrate contents of the 1X treatments are similar to the control.

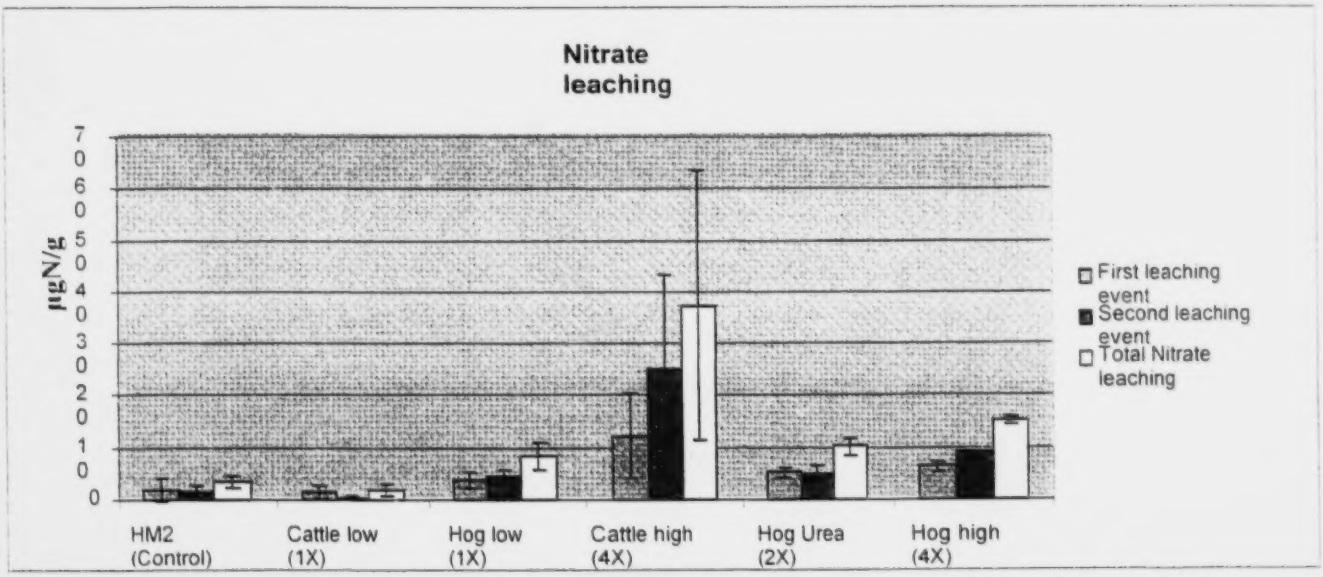


Figure 18. Nitrate nitrogen (ug nitrate-N per gram of soil) leached from intact soil cores collected in Fall 2004 at the end of the cropping season from Dixon site. First leaching event denotes nitrate leached from 5cm of water applied in week one. Second leaching event denotes nitrate leached from another 5 cm of water applied in week two.

The high rate of cattle manure (4X annual addition rate) produced the highest amount of nitrate leached from the 0-15 cm depth cores. As the soil nitrate content of the cattle manure treatments is typically lower than for the swine manure treatments due to the preponderance of N added in organic forms in cattle manure, the high nitrate leaching can be attributed to higher production of nitrate by mineralization in the cattle manure treatment during the after-harvest period before sampling and also during the incubation, owing to the build-up of organic N and mineralizable N from past years of cattle manure application. These results support the concept that at the 1X annual application rate, annual addition of manure does not pose a potential leaching problem, but that at excessive 4X annual application rates, enhanced nitrate leaching below the root zone is an issue, as observed in the field sampling.

CONCLUSIONS AND RECOMMENDATIONS

The results of this study clearly show that annual applications of liquid swine manure that equate to about 100 kg N/ha or 3000 to 4000 gallons per acre based on typical N content, maximize crop yield over time and minimize concern about nitrogen and phosphorus loading of the soil. Double or triple these rates applied once every second or third year respectively also did not show evidence of nitrogen or phosphorus loading or migration. Significant residual effects into the second and third year of these larger swine manure applications are apparent, but additional fertilizer nutrient may be required to maximize yield in subsequent years. Yield benefits are obtained not only from nitrogen in the manure but also from other nutrients as evidenced by the consistent manner in which manure out-yielded commercial urea-only fertilizer treatments due to the P and other nutrients added in the manure. As has been consistently observed for the last ten years of monitoring, injecting the liquid swine manure consistently produces higher yield and N recovery than broadcast and incorporating the manure. Over- application of swine manure, as in application at ~ 400 kg N/ha every year, resulted in significantly lower crop recovery of swine manure N , subsequent accumulation of nitrate in the soil profile over the years, and evidence of deep leaching below 60cm. Excessive rates were also occasionally associated with reduced crop yield. This was most evident where manure N addition over the years was large and crop removal was reduced due to drought as at the Plenty site. Irrigation, as at the Riverhurst site, reduced the apparent soil N loading due to greater crop nutrient removal, but may also reflect greater N losses from the system over the years. At the Plenty site, the impact of over-application several years past became evident now in the present study with significant accumulations of nitrate in the sub–soil. It is recommended that application rates of manure be used that are in balance with crop requirement and nutrient removal over time, as these avoid nutrient loading and subsequent escape, and resulted in maximum yield and economic benefit achieved from the manure.

Addition of a nitrification inhibitor to the liquid swine manure did not significantly affect final crop yield, N uptake or N recovery by wheat in 2005 or flax in 2006 at the Dixon site. The nitrification inhibitor did appear to keep more of the inorganic nitrogen in the ammonium form and less in the nitrate form, reducing the loss potential. There were some small but significant effects early in the season with the inhibitor contributing to increased recovery and biomass yield, but the effects at harvest were diminished. Overall, it would appear that the loss potential for nitrate under Saskatchewan conditions was not great enough for the inhibitor to show a substantial effect on increasing recovery of manure N. Similarly, the use of supplemental P and S fertilizer at Dixon and Melfort sites respectively significantly increased yield and N recovery by the crop in the urea-only fertilized treatments but not the manure treatments, indicating that for the two years of the study and with the crops grown, the manure supplied sufficient P and S for crop growth. This was also born out by the soil test extractable P and S amounts and the P and S concentrations in the plant. It should be noted however, that in previous years, responses have sometimes been observed with P fertilization and S fertilization at these

two sites in the manure treatments. Soil test levels, crop nutrient requirement, and manure P and S levels should all be assessed and considered when assessing potential responses to applied manure nutrients and the need for supplemental commercial fertilizer.

The results from the cattle manure trials at Dixon point out some key differences in the behavior of solid cattle manure as a nutrient source compared to liquid swine manure. In both years of the study, the 4X annual application rate of cattle manure (~300-400 kg N/ha) was needed to produce the highest yield because of the low short-term availability of cattle manure nitrogen. The yields were reduced with lower annual application rates and reduced application frequency. However, relying on rates of cattle manure high enough to supply enough N on its own can result in loading and increased risk of loss of other nutrients like phosphorus to environment. These rates of cattle manure resulted in accumulations of extractable P > 100 kg/ha in the 0-15 cm depth, evidence of migration of P into the 15-30cm depth in the field, and the highest leaching of nitrate and phosphorus observed in the core leaching experiment. It is recommended that one should only attempt to supply a portion of the N requirement with cattle manure, follow the P requirement and monitor soil P levels closely, meeting the additional N requirements with use of supplemental N fertilizer or growing legumes that can fix their own N.

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Appendix A

Use of a Nitrification Inhibitor to Improve Crop Recovery of Manure Nutrients

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Key Words: nitrogen recovery, PRS probes, nitrification inhibitor

Abstract

Intensive hog operations generate large amounts of manure that must be dealt with in a manner that is both economically and environmentally sound. The objective of the research described is to evaluate the effect of adding a nitrification inhibitor as means of enhancing crop recovery of manure nitrogen. A long - term swine manure field trial located on a Black Chernozem (Cudworth Association) near Dixon, SK was used in the study. A nitrification inhibitor (DCD) was added to liquid swine manure that was applied using low disturbance injection in the spring of 2005. The application rate of nitrogen in this treatment was ~ 75 kg N $\cdot$ ha^{-1} per year. This was compared to the same rate of liquid swine manure applied without the inhibitor. The efficacy of the nitrification inhibitor was evaluated by measurement of plant nitrogen recovery. As well, PRS^{TM} probes (anion and cation exchange membranes) were used to assess ammonium and nitrate supply rates in the soil during the growing season as affected by treatment. Plant samples were also taken biweekly during the growing season to quantify biomass production and measure plant nitrogen uptake in the selected treatments. Data obtained in the 2005 season indicates that the nitrification inhibitor was effective in keeping more of the manure nitrogen in the ammonium form during the 2005 season at the Dixon site. However, significant increases in crop nitrogen recovery, and yield responses were not observed from the use of the nitrification inhibitor at the Dixon site. This may be explained by conditions during the growing season that were not conducive to high potential losses of nitrate by leaching or denitrification.

Introduction

Intensive hog operations are capable of generating large amounts of manure. This manure must be dealt with in such a way that is economical and environmentally friendly. Previous work has been done in the area of phosphorus and nitrogen loading (Stumborg C.M. et al. 2005). The focus of this experiment is to examine possible ways

of increasing the plant uptake of manure nitrogen applied to the soil. The goal is to use the nitrogen supplied in the manure more efficiently.

Hypothesis and Objective

The hypothesis of the experiment is that the addition of a nitrification inhibitor to swine manure will lead to an increased recovery of manure nitrogen. The objective is to evaluate the role of a nitrification inhibitor as a means to increase the utilization of manure nitrogen by crops

Materials and Methods

The experimental site was located at Dixon, Saskatchewan. The soil at the Dixon site is a Black Chernozem of the Cudworth Association, with a loamy surface texture formed on silty lacustrine material. Test plots were 30.5 meters long by 3.05 meters wide. The experiment was a randomized complete block design (RCBD) replicated 4 times. Hard red spring wheat (Intrepid) was the crop grown during the 2005 growing season. The treatments of interest were the control, 1X and 1X + nitrification inhibitor.
The control treatment did not receive any manure or fertilizer. The 1X treatment represents the one times recommended agronomic rate of 37,000 L ha^{-1} of swine manure. The nitrification inhibitor used in the experiment was Super N Concentrate. Super N Concentrate contains both a nitrification and urease inhibitor. Dicyandiamide (DCD) is the nitrification inhibitor and N-(butyl) thioshosphoric triamide (NBPT) is the urease inhibitor. It was anticipated that the majority, if not all of the inhibition, will be from the DCD, as all or most of the urea in the manure would have already undergone hydrolysis by the time of manure application. Soil samples were taken for the treatments of interest prior to manure application. Plant samples were taken biweekly until the crop reached the dough stage. Biweekly plant samples allowed for determination of nitrogen uptake over time. PRS probes were placed in the soil two weeks after seeding. PRS probes were removed and replaced every two weeks throughout the growing season, which allowed for monitoring of nitrogen supply rates. Four anion and four cation PRS probes were placed in treatment plots of interest. The PRS probes were placed in PVC cores in an attempt to exclude root competition. All manure fertilizers were injected into the soil with Bourgault coulter openers.

Results and Discussion

Supply rates of ammonium in the soil over five two week time periods throughout the growing season are shown in Figure 1. The manure fertilizer treatment that received the nitrification inhibitor revealed significantly more nitrogen supplied in the ammonium form as compared to the treatment that did not receive the inhibitor. This shows that the inhibitor is keeping the nitrogen in the ammonium form longer, and preventing the conversion of ammonium to nitrate.

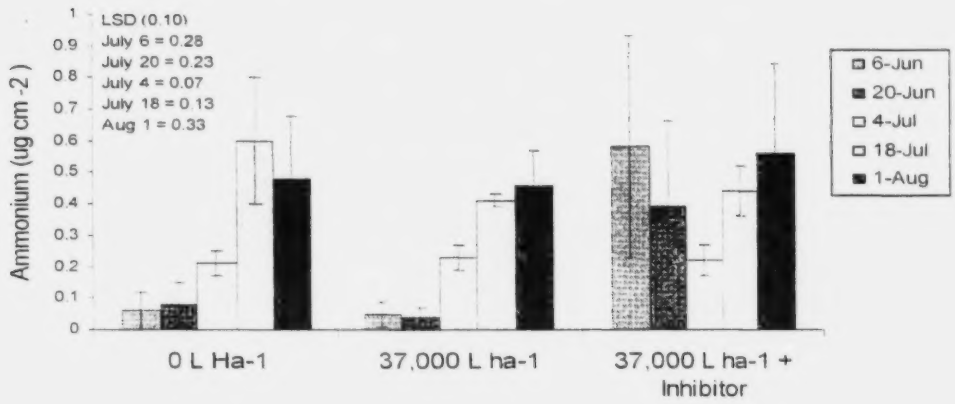

Figure 1. Ammonium supply rate for three manure treatments over time.

Supply rates of nitrate over five two week time periods were highest in the 37,000 L h^{-1} treatment (without nitrification inhibitor), and slightly lower in the 37,000 L h^{-1} + nitrification inhibitor (Figure 2). Lower supply rates of nitrate are expected from the 37,000 L h^{-1} + nitrification inhibitor treatment as the conversion of ammonium to nitrate is slowed.

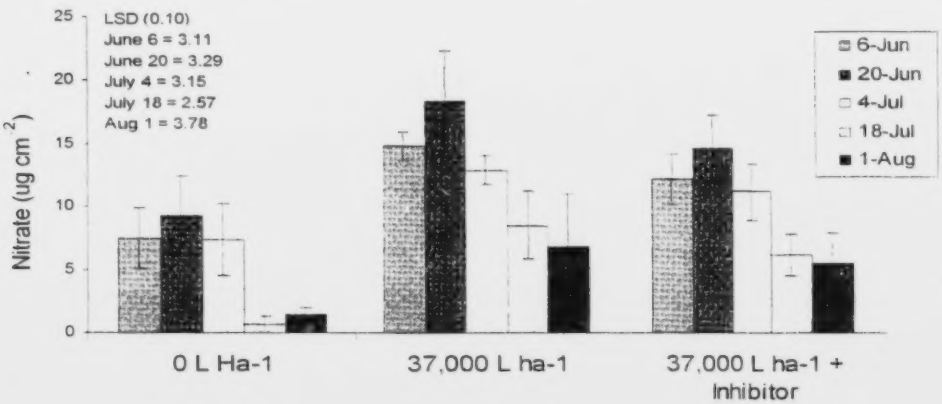

Figure 2. Nitrate supply rate for three manure treatments over time.

There were no significant differences in biomass production over the growing season between the manure treatments until the last sampling period (Figure 3). Slightly higher biomass production was observed in the 37,000 L h^{-1} + nitrification inhibitor treatment as compared to the 37,000 L h^{-1} treatment without the inhibitor on the last sampling date.

The higher biomass production may be related to the addition of the nitrification inhibitor.

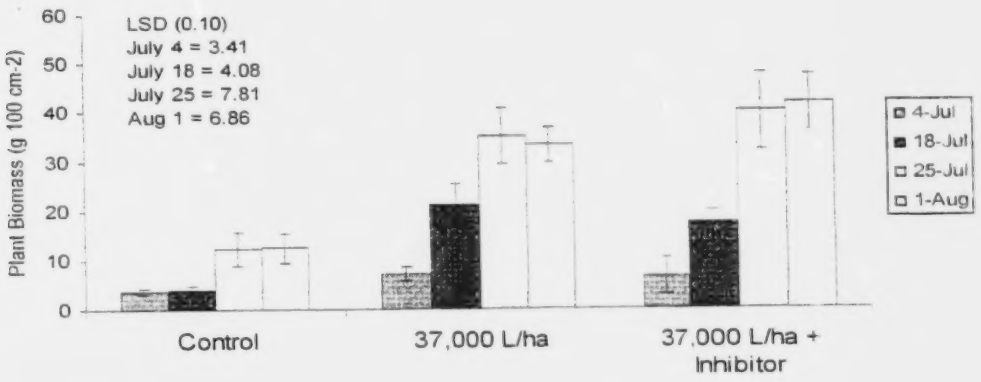

Figure 3. Plant biomass production for three manure treatments over time.

Nitrogen uptake was calculated using the biweekly biomass samples collected during the growing season. Data was then normalized to make the N uptake of unfertilized control equal to 100% uptake. The N uptake in the 37,000 L ha^{-1}, and 37,000 L ha^{-1} + nitrification inhibitor treatments are shown relative to the uptake of the controls for their respective sampling dates (Figure 4). No significant effects in nitrogen uptake were observed, with the exception of July 25 sampling date. The increase in nitrogen uptake on July 25, could be the effect of the nitrification inhibitor on conserving more N.

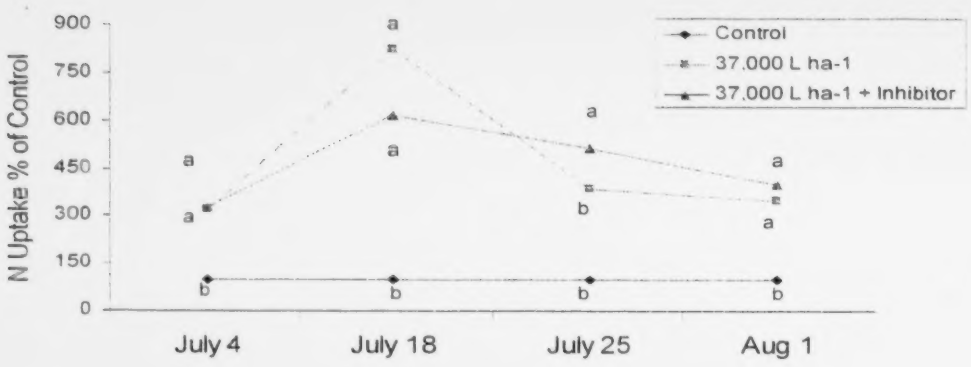

Figure 4. Normalized data of nitrogen uptake of three manure treatments as a percent of control over time. Data is presented as a percent compared to control.

In terms of final grain yield (Figure 5) no significant differences were observed between the 37,000 L ha^{-1} and 37,000 L ha^{-1} + nitrification inhibitor treatment in the 2005 field season.

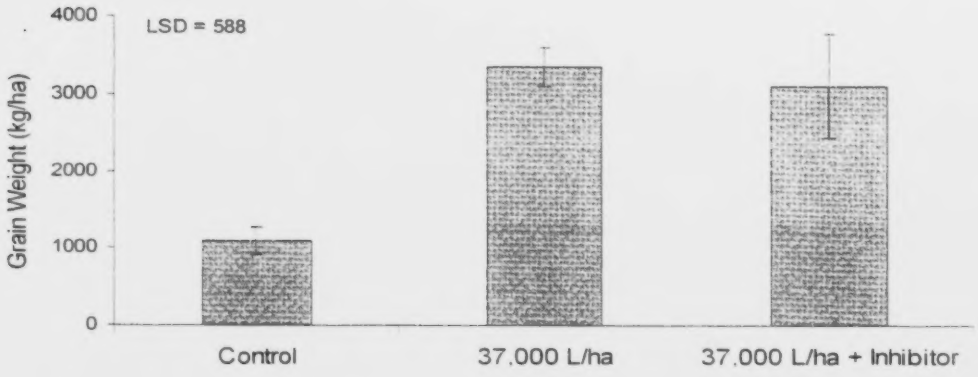

Figure 5. Grain yield production for three manure treatments for the 2005 growing season at Dixon experimental site.

Discussion

The addition of a nitrification inhibitor to swine manure was effective in maintaining nitrogen in the ammonium form longer compared to manure that had not received the inhibitor. In a fertilizer study using a dicyandiamide and urea fertilizer Gioacchini et al. (2002) found that the use of a nitrification inhibitor can maintain nitrogen as ammonium for a longer time compared to urea that is left untreated. Vallejo et al. (2005) found that soil ammonium concentrations declined less rapidly in swine manure treatments which received a nitrification inhibitor added to the manure. Overall the nitrification inhibitor appears to be effective in maintaining nitrogen in the ammonium form longer early in the growing season, but no significant increase in grain yield were observed in the 2005 growing season.

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Equipment

None

Expense Statement

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